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U.S. Geological Survey

MINERALS YEARBOOK

Metals and Minerals 2010

Volume I

U.S. DEPARTMENT OF THE INTERIOR
KEN SALAZAR, Secretary

U.S. GEOLOGICAL SURVEY
Marcia K. McNutt, Director

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Foreword

This edition of the U.S. Geological Survey (USGS) Minerals Yearbook discusses the performance of the worldwide minerals and materials industries during 2010 and provides background information to assist in interpreting that performance. Content of the individual Minerals Yearbook volumes follows:

- Volume I, Metals and Minerals, contains chapters about virtually all metallic and industrial mineral commodities important to the U.S. economy. Chapters on survey methods, summary statistics for domestic nonfuel minerals, and trends in mining and quarrying in the metals and industrial mineral industries in the United States are also included.
- Volume II, Area Reports: Domestic, contains a chapter on the mineral industry of each of the 50 States and Puerto Rico and the Administered Islands. This volume also has chapters on survey methods and summary statistics of domestic nonfuel minerals.
- Volume III, Area Reports: International, is published as four separate reports. These regional reports contain the latest available minerals data on more than 180 foreign countries and discuss the importance of minerals to the economies of these nations and the United States. Each report begins with an overview of the region's mineral industries during the year. It continues with individual country chapters that examine the mining, refining, processing, and use of minerals in each country of the region and how each country's mineral industry relates to U.S. industry. Most chapters include production tables and industry structure tables, information about Government policies and programs that affect the country's mineral industry, and an outlook section.

The USGS continually strives to improve the value of its publications to users. Constructive comments and suggestions by readers of the Minerals Yearbook are welcomed.

Marcia K. McNutt, Director

Contacts

Information about the U.S. Geological Survey, its programs, staff, and products may be accessed on the Internet at http://www.usgs.gov or by contacting the Earth Science Information Center at 1-888-ASK-USGS. For specific information about this publication, contact the Chief, Mineral Commodities Section, at (703) 648-4976; or the Team Secretary at (703) 648-4961. Additional minerals information may be accessed on the Internet at http://minerals.usgs.gov/minerals.

Acknowledgments

Volume I, Metals and Minerals, of the Minerals Yearbook presents data on more than 80 minerals and materials that were collected as a result of the information gathering activities of the U.S. Geological Survey.

The collection, compilation, and analysis of domestic mineral industry data were performed by the staff of the National Minerals Information Center. Statistical data were compiled from information supplied by mineral producers and consumers in response to canvasses, and their responses are greatfully appreciated. Information obtained from individual firms by means of the U.S. Geological Survey canvasses has been grouped to provide statistical aggregates. Data on individual firms are presented only if available from published or other nonproprietary sources or when permission of the respondent has been granted. The chapters on "Survey Methods of Nonfuel Minerals" and "Statistical Summary" discuss in greater detail procedures for canvassing the mineral industry and the processing and evaluation of these data. Other information appearing in this volume was obtained from the trade and technical press, industry contacts, and additional sources; this cooperation is gratefully acknowledged.

Statistics on world production were compiled from numerous sources, including reports from the U.S. Department of State. U.S. foreign trade data were obtained from reports of the U.S. Department of Commerce, U.S. Census Bureau. The U.S. Geological Survey also was assisted by numerous cooperating State agencies.

John H. DeYoung, Jr.
Director, National Minerals Information Center

Contents

Page

Foreword, by Marcia K. McNutt iii
Contacts iv
Acknowledgments, by John H. DeYoung, Jr. v
Survey methods for nonfuel minerals, by Jeffrey P. Busse 1.1
Statistical summary, by Joseph M. Krisanda 2.1
Mining and quarrying trends, by Mary E. Ewell 3.1
Abrasives, manufactured, by Donald W. Olson 4.1
Aluminum, by E. Lee Bray 5.1
Antimony, by James F. Carlin, Jr. 6.1
Arsenic, by William E. Brooks 7.1
Asbestos, by Robert L. Virta 8.1
Barite, by M. Michael Miller 9.1
Bauxite and alumina, by E. Lee Bray 10.1
Beryllium, by Brian W. Jaskula 11.1
Bismuth, by James F. Carlin, Jr. 12.1
Boron, by Marc A. Angulo and Robert D. Crangle, Jr. 13.1
Bromine, by Joyce A. Ober 14.1
Cadmium, by Amy C. Tolcin 15.1
Cement, by Hendrik G. van Oss 16.1
Chromium, by John F. Papp 17.1
Clay and shale, by Robert L. Virta 18.1
Cobalt, by Kim B. Shedd 19.1
Copper, by Daniel L. Edelstein 20.1
Diamond, industrial, by Donald W. Olson 21.1
Diatomite, by Robert D. Crangle, Jr. 22.1
Explosives, by Lori E. Apodaca 23.1
Feldspar and nepheline syenite, by Arnold O. Tanner 24.1
Ferroalloys, by Lisa A. Corathers, Joseph Gambogi, Peter H. Kuck, John F. Papp, Désirée E. Polyak, and Kim B. Shedd 25.1
Fluorspar, by M. Michael Miller 26.1
Gallium, by Brian W. Jaskula 27.1
Garnet, industrial, by Donald W. Olson 28.1
Gemstones, by Donald W. Olson 29.1
Germanium, by David E. Guberman 30.1
Gold, by Micheal W. George 31.1
Graphite, by Donald W. Olson 32.1
Gypsum, by Robert D. Crangle, Jr. 33.1
Helium, by Joseph B. Peterson and Peter J. Madrid 34.1
Indium, by Amy C. Tolcin 35.1
Iodine, by Marc A. Angulo 36.1
Iron and steel, by Michael D. Fenton 37.1
Iron and steel scrap, by Michael D. Fenton 38.1
Iron ore, by John D. Jorgenson 39.1
Iron oxide pigments, by Arnold O. Tanner 40.1
Kyanite and related materials, by Arnold O. Tanner 41.1
Lead, by David E. Guberman 42.1
Lime, by M. Michael Miller 43.1
Lithium, by Brian W. Jaskula 44.1
Magnesium, by Deborah A. Kramer 45.1
Magnesium compounds, by Deborah A. Kramer 46.1
Manganese, by Lisa A. Corathers 47.1
Mercury, by William E. Brooks 48.1
Mica, by Jason Christopher Willett 49.1
Molybdenum, by Désirée E. Polyak 50.1
Nickel, by Peter H. Kuck 51.1
Niobium (columbium) and tantalum, by John F. Papp 52.1
Nitrogen, by Lori E. Apodaca 53.1
Peat, by Lori E. Apodaca 54.1

Contents—Continued

Page

Perlite, by Wallace P. Bolen 55.1
Phosphate rock, by Stephen M. Jasinski 56.1
Platinum-group metals, by Patricia J. Loferski 57.1
Potash, by Stephen M. Jasinski 58.1
Pumice and pumicite, by Robert D. Crangle, Jr. 59.1
Rare earths, by Joseph Gambogi and Daniel J. Cordier 60.1
Recycling—Metals, by John F. Papp 61.1
Rhenium, by Désirée E. Polyak 62.1
Salt, by Dennis S. Kostick 63.1
Sand and gravel, construction, by Wallace P. Bolen 64.1
Selenium and tellurium, by Micheal W. George 65.1
Silica, by Thomas P. Dolley 66.1
Silicon, by Lisa A. Corathers 67.1
Silver, by William E. Brooks 68.1
Slag—Iron and steel, by Hendrik G. van Oss 69.1
Soda ash, by Dennis S. Kostick 70.1
Stone, crushed, by Jason Christopher Willett 71.1
Stone, dimension, by Thomas P. Dolley 72.1
Strontium, by Marc A. Angulo 73.1
Sulfur, by Lori E. Apodaca 74.1
Talc and pyrophyllite, by Robert L. Virta 75.1
Thorium, by E. Lee Bray 76.1
Tin, by James F. Carlin, Jr. 77.1
Titanium, by Joseph Gambogi 78.1
Tungsten, by Kim B. Shedd 79.1
Vanadium, by Désirée E. Polyak 80.1
Vermiculite, by Arnold O. Tanner 81.1
Wollastonite, by Robert L. Virta 82.1
Zeolites, by Robert L. Virta 83.1
Zinc, by Amy C. Tolcin 84.1
Zirconium and hafnium, by Joseph Gambogi 85.1

SURVEY METHODS FOR NONFUEL MINERALS

By Jeffrey P. Busse

The U.S. Geological Survey (USGS) collects worldwide data on virtually every commercially important nonfuel mineral commodity. These data form the basis for tracking and assessing the health of the minerals sector of the U.S. economy.

The USGS data collection activity was instituted by the 47th Congress in the appropriations act of August 7, 1882 (22 Stat. 329), which placed the collection of mineral statistics on an annual basis. The most recent authority for the USGS survey activity is the National Materials and Minerals Policy, Research and Development Act of 1980 (Public Law 96–479, 94 Stat. 2305). The Act included provisions to strengthen protection for proprietary data provided to the U.S. Department of the Interior by persons or firms engaged in any phase of mineral or mineral-material production or consumption.

Data Collection Surveys

The USGS begins the collection of domestic nonfuel minerals and materials statistics by appraising the information requirements of government and private organizations of the United States. Requirements that can be met by collecting data from minerals establishments are posed as questions on USGS surveys. Figure 1 shows a typical survey form.

Specific questions about mineral commodity activities, such as production, shipments, consumption, and recycling are structured in the survey forms to provide meaningful aggregated data. Thus, the entire mineral economic cycle from exploration and production through recycling is covered by approximately 150 monthly, quarterly, semiannual, and annual surveys.

After the survey form has been designed, a list of the appropriate establishments to be canvassed is developed. Many sources are used to determine which companies, mines, plants, and other operations are included on the survey mailing list. State geologists, Federal organizations (such as the Mine Safety and Health Administration), trade associations, industry representatives, and trade publications and directories are some of the sources that are used to develop and update survey listings. With few exceptions, a complete census of the list of establishments is used rather than a sample survey.

The Paperwork Reduction Act requires that any Government agency that wants to collect information from 10 or more individuals or establishments must first obtain approval from the Office of Management and Budget (OMB), which approves the need to collect the data and protects industry from unwarranted Government paperwork. This approval is indicated by the OMB control number on the survey forms (figure 1).

Survey Processing

The USGS surveys approximately 20,000 establishments. Each year, the USGS mails about 32,000 forms for approximately 150 different surveys. Each completed survey form returned to the USGS undergoes extensive analysis, including computerized checks, to ensure the highest possible accuracy of the mineral data. The statistical staff monitors all surveys to ensure that errors are not created by reporting in physical units different from the units requested on the form. Relations between associated measures, such as produced crude ore and marketable crude ore, are analyzed for consistency. Engineering variables, such as recovery factors from ores and concentrates, also are used. The totals for each form are verified, and currently reported data are checked against prior reports to detect possible errors or omissions.

The USGS has developed a Web-based electronic forms system as required by the Government Paperwork Elimination Act (GPEA). This electronic system was designed to speed the collection and analysis of minerals information. As of December 2010, approximately 100 canvass forms, accounting for all the annual responses covered by GPEA, are available electronically.

Survey Responses.—To enable the reader to better understand the basis on which the statistics are calculated, each mineral commodity chapter includes a section about domestic data coverage. This section briefly describes the data sources, the number of establishments surveyed, the response percentage, and the method of estimating the production or consumption for nonrespondents.

To produce reliable aggregated data, the USGS uses efficient procedures for handling instances of nonresponse. Failure to respond to the initial survey results in a second contact, this is either a second mailing of the paper form or an email in the case of electronic respondents. If the second request does not produce a response, then telephone calls are made to the nonrespondents. The followup calls provide the necessary data to complete the survey forms and (or) to verify questionable data entries. Periodic visits to mineral establishments also are made by USGS mineral commodity specialists to gather missing data and to explain the importance of the establishment's reporting. By describing the use of the published statistics and showing the impact of nonresponse, the USGS strives to encourage respondents to give complete and accurate replies.

The OMB publication "Guidelines for Reducing Reporting Burden" stipulates that the minimum acceptable response rate is 75% of the panel surveyed. In addition, the USGS strives for a minimum reporting level of 75% of the quantity produced or consumed (depending on the survey) for certain key statistics. Response rates are periodically reviewed. For those surveys that do not meet the minimum reporting level, procedures are developed and implemented to improve response rates.

Estimation for Nonresponse.—When efforts to obtain a response to a survey fail, estimation or imputation techniques must be used to account for missing data. Some of the estimation methods depend on knowledge of prior establishment reporting; other techniques rely on external information to estimate the missing data. When survey forms are received after the current publication has been completed, the forms are reviewed, necessary imputations are made for missing data, and the survey database is updated. The revised data are reported in later publications.

Protection of Proprietary Data.—The USGS relies on the cooperation of the U.S. minerals industry to provide the mineral data that are presented in this and other USGS minerals information publications. Without a strong response to survey requests, the USGS would not be able to present reliable statistics. The USGS, in turn, respects the proprietary nature of the data received from the individual companies and establishments. To ensure that proprietary rights will not be violated, the USGS analyzes each of the aggregated statistics to determine if the data reported by an individual establishment can be deduced from the aggregated statistics. If, for example, there are only two significant producers of a mineral commodity in a given State, then the USGS will not publish the State total because either producer could readily estimate the production of the other. It is this obligation to protect proprietary information that results in the withheld entries indicated with the symbol "W" in the published tables. If a company gives permission in writing, however, then the USGS will publish the data as long as the data from other respondents are protected from disclosure.

International Data

International data are collected by USGS country specialists and international data coordinators. The data are gathered from various sources, which include published reports of foreign Government mineral and statistical agencies, international organizations, the U.S. Department of State, the United Nations, the Organization of the Petroleum Exporting Countries, and personal contact by specialists traveling abroad. Each February, minerals questionnaires requesting estimates of mineral production for the country for the preceding year are sent to foreign organizations. Missing data are estimated by USGS country specialists on the basis of historical trends and the specialist's knowledge of current production capabilities in each country.

Publications

The USGS disseminates current and historical minerals information through printed publications and its Web site.

Printed Publications.—The Minerals Yearbook summarizes annually, on a calendar-year basis, the significant economic and technical developments in the mineral industries. Three volumes are issued each year—volume I, Metals and Minerals; volume II, Area Reports: Domestic; and volume III, Area Reports: International. Volume I presents, by mineral commodity, salient statistics on production, trade, consumption, and other measures of economic activity. Volume II reviews the U.S. minerals industry by State and island possessions. Volume III is published as four separate regional reports that cover more than 175 foreign countries; these reports contain individual country chapters that examine the mining, refining, processing, and use of minerals in each country in the region and how they relate to U.S. industry. Volume III chapters also contain information on fuels.

The Mineral Commodity Summaries (MCS), which is an up-to-date summary of more than 90 individual minerals and materials, is the earliest Government publication to furnish estimates that cover the previous year's nonfuel mineral industry data. It contains information on the domestic industry structure, Government programs, tariffs, 5-year salient domestic statistics, and a summary of significant events, trends, and issues in the domestic and international minerals industry during the past year.

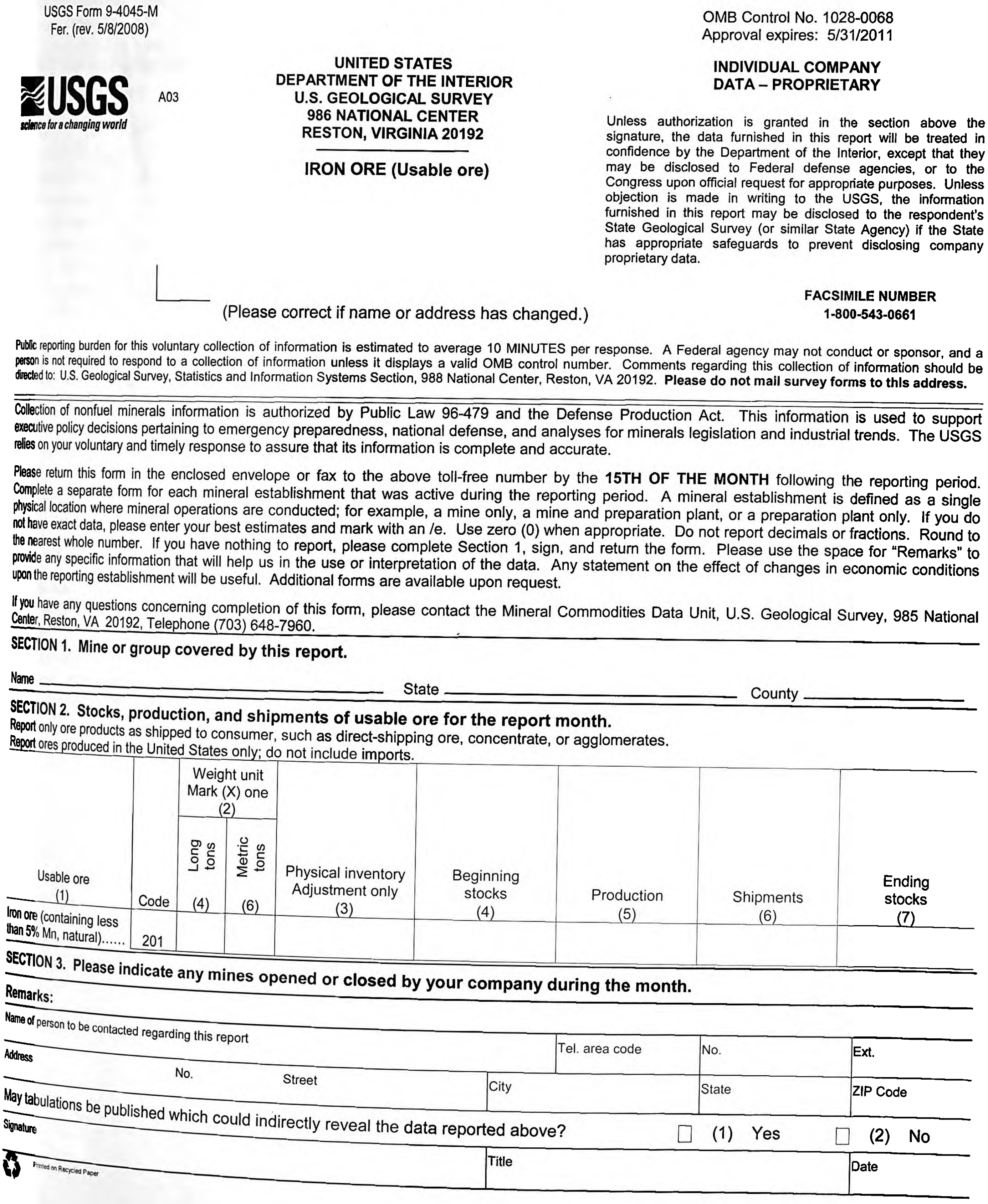
The Minerals Yearbook and the MCS may be purchased by mail from the U.S. Government Printing Office, P.O. Box 979050, St. Louis, MO 63197–9000; telephone, (202) 512–1800 or (866) 512–1800 (toll-free); Web site, http://bookstore.gpo.gov.

Electronic Publications.—Current and historical minerals information is available through the USGS Web site at http://minerals.usgs.gov/minerals/. The Web site provides USGS minerals information products as well as USGS contacts for minerals information and links to other mineral-related sites on the Internet.

Mineral Industry Surveys (MISs) contain timely statistical and economic data on minerals. The surveys are designed to keep government agencies and the public, particularly the mineral industry and the business community, informed of trends in the production, distribution, inventories, and consumption of minerals. Frequency of issue depends on the demand for current data. MISs are released monthly, quarterly, or annually.

The Metal Industry Indicators (MII) report, which is published monthly, contains indexes that measure the current and future performance of three U.S. metal industries. For each of the three industries, a composite coincident index and a composite leading index have been developed based on procedures and data similar to those used to construct The Conference Board's coincident and leading cyclical indexes for the national economy. MIIs also contain several indicators for metal prices. Nonmetallic Mineral Products Industry Indexes, also published monthly, contains leading and coincident indexes that measure the current and future performance of the industrial minerals industry. The indexes were designed by using the same procedures as the USGS metal composite indexes.

FIGURE 1
A TYPICAL SURVEY FORM



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A03

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Collection of nonfuel minerals information is authorized by Public Law 96-479 and the Defense Production Act. This information is used to support executive policy decisions pertaining to emergency preparedness, national defense, and analyses for minerals legislation and industrial trends. The USGS relies on your voluntary and timely response to assure that its information is complete and accurate.

Please return this form in the enclosed envelope or fax to the above toll-free number by the **15TH OF THE MONTH** following the reporting period. Complete a separate form for each mineral establishment that was active during the reporting period. A mineral establishment is defined as a single physical location where mineral operations are conducted; for example, a mine only, a mine and preparation plant, or a preparation plant only. If you do not have exact data, please enter your best estimates and mark with an /e. Use zero (0) when appropriate. Do not report decimals or fractions. Round to the nearest whole number. If you have nothing to report, please complete Section 1, sign, and return the form. Please use the space for "Remarks" to provide any specific information that will help us in the use or interpretation of the data. Any statement on the effect of changes in economic conditions upon the reporting establishment will be useful. Additional forms are available upon request.

If you have any questions concerning completion of this form, please contact the Mineral Commodities Data Unit, U.S. Geological Survey, 985 National Center, Reston, VA 20192, Telephone (703) 648-7960.

SECTION 1. Mine or group covered by this report.

Name __________ State __________ County __________

SECTION 2. Stocks, production, and shipments of usable ore for the report month.
Report only ore products as shipped to consumer, such as direct-shipping ore, concentrate, or agglomerates.
Report ores produced in the United States only; do not include imports.

Usable ore (1)	Code	Weight unit Mark (X) one (2)		Physical inventory Adjustment only (3)	Beginning stocks (4)	Production (5)	Shipments (6)	Ending stocks (7)
		Long tons (4)	Metric tons (6)					
Iron ore (containing less than 5% Mn, natural)......	201							

SECTION 3. Please indicate any mines opened or closed by your company during the month.

Remarks:

Name of person to be contacted regarding this report	Tel. area code	No.	Ext.
Address No. Street	City	State	ZIP Code

May tabulations be published which could indirectly reveal the data reported above? ☐ (1) Yes ☐ (2) No

Signature	Title	Date

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STATISTICAL SUMMARY

By Joseph M. Krisanda

The world production table was prepared by Glenn J. Wallace, international data coordinator.

This annual report summarizes data on crude nonfuel mineral production[1] for the United States, its island possessions, and the Commonwealth of Puerto Rico.

Although crude mineral production may be measured at any of several stages of extraction and processing, the stage of measurement used in this annual report is what is termed "mine output." This term refers to minerals or ores in the form in which they are first extracted from the ground, but customarily may include the output from auxiliary processing at or near the mines.

Because of inadequacies in the statistics available, some series deviate from the foregoing definition. For copper, gold, lead, silver, and zinc, the quantities listed are recorded on a mine basis (as the recoverable content of ore sold or treated). The values assigned to the quantities, however, are based on the average selling price of refined metal, not the mine value.

The total value of all nonfuel mineral production in the United States in 2010 increased to $66.4 billion, which was a 13% increase compared with that of 2009; metals increased to $30.4 billion, which was an increase of 39%; and industrial minerals decreased to $36.0 billion, a decrease of 2%.

In 2010, the value of nonfuel mineral commodity production for the following 13 mined commodities, in descending order of production value, was greater than $1 billion: stone (crushed), gold, copper, cement (portland), sand and gravel (construction), iron ore (usable shipped), molybdenum concentrates, phosphate rock (marketable), lime, salt, zinc, soda ash, and sand and gravel (industrial). They accounted for 88% of the U.S. total production value (table 1).

In 2010, the value of nonfuel mineral commodity production in the following 21 States, in descending order of production value, was greater than $1 billion: Nevada, Arizona, Utah, Minnesota, Alaska, California, Texas, Florida, Michigan, Missouri, Wyoming, Colorado, Pennsylvania, Georgia, New York, Idaho, Ohio, Montana, Kansas, Virginia, and New Mexico. They accounted for 81% of the U.S. total production value (table 3).

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[1] The terms "nonfuel mineral production" and related "values" encompass variations in meaning, depending upon the mineral products. Production may be measured by mine shipments, mineral commodity sales, or marketable production (including consumption by producers) as is applicable to the individual mineral commodity.

All 2010 U.S. Geological Survey (USGS) mineral production data published in this chapter are as of June 2012. For some mineral commodities, such as construction sand and gravel, crushed stone, and portland cement, estimates are updated periodically. To obtain the most current information, please contact the appropriate USGS mineral commodity specialist. Specialist contact information is available on the Internet at http://minerals.usgs.gov/minerals/contacts/comdir.html; alternatively, specialists' names and telephone numbers may be obtained by calling USGS information at (703) 648-4000 or by calling the USGS Earth Science Information Center at 1-888-ASK-USGS (275-8747). Minerals Yearbook chapters (for mineral commodities, States, and countries) and Mineral Industry Surveys are also available on the Internet at http://minerals.usgs.gov/minerals.

TABLE 1
NONFUEL MINERAL PRODUCTION IN THE UNITED STATES[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral		2008		2009		2010	
		Quantity	Value	Quantity	Value	Quantity	Value
Metals:							
Beryllium concentrates[4]	metric tons	4,410	NA	3,030	NA	4,460	NA
Cadmium[e, 5]	do.	2,990	17,700	2,840	8,140	2,890	11,300
Copper[6]		1,310	9,200,000	1,180	6,280,000	1,110	8,520,000
Gold[6]	kilograms	233,000	6,550,000	223,000	7,000,000	231,000	9,130,000
Iron ore, usable shipped		53,600	3,770,000	27,600	2,560,000	50,600	5,000,000
Lead[6]	metric tons	399,000	1,060,000	395,000	757,000	356,000	854,000
Molybdenum concentrates[7]	do.	55,900	3,830,000	47,800	2,870,000	59,400	3,580,000
Palladium[6]	kilograms	11,900	136,000	12,700	108,000	11,600	199,000
Platinum[6]	do.	3,580	182,000	3,830	149,000	3,450	179,000
Silver[6]	do.	1,250,000	600,000	1,250,000	588,000	1,280,000	829,000
Zinc[6]	metric tons	748,000	1,470,000	710,000	1,220,000	723,000	1,620,000
Combined values of magnesium metal, titanium concentrates, tungsten, zirconium concentrates		XX	518,000	XX	345,000	XX	451,000
Total		XX	27,300,000	XX	21,900,000	XX	30,400,000
Industrial minerals, excluding fuels:[8]							
Barite		648	30,900	383	19,900	662	37,200
Cement:[9]							
Masonry		3,030	428,000 [e]	1,970	269,000 [e]	1,900	251,000 [e]
Portland		83,300	8,390,000 [e]	61,900 [r]	5,950,000 [r, e]	64,500	5,870,000 [e]
Clays:							
Ball		968	44,300	831	37,700	912	41,300
Bentonite		4,910	267,000	3,650	207,000	4,630	261,000
Common		17,500	202,000	12,500	156,000	12,100	148,000
Fire		296	11,800	320	12,000	216	6,120
Fuller's earth		2,340 [10]	230,000 [10]	2,010 [10]	206,000 [10]	2,050 [10]	201,000 [10]
Kaolin		6,740	900,000	5,290	714,000	5,420	788,000
Diatomite		764	171,000	575	147,000	595	178,000
Feldspar[9]		650 [11]	40,000	550 [11]	35,600	550 [11]	33,500
Garnet, industrial[9]	metric tons	62,900	13,600	45,600	6,850	52,600	7,910
Gemstones, natural[9]		NA	11,500	NA	9,310 [r]	NA	10,000
Gypsum, crude[9]		12,300	91,200	10,400	77,400	8,840	60,900
Helium:							
Crude	million cubic meters	42	90,100	40	85,700	49	115,000
Grade–A	do.	130	630,000	118 [r]	572,000	129	697,000
Kyanite		97	25,500	71	21,000 [r]	93	28,000
Lime		19,800	1,830,000	15,800	1,650,000	18,300	1,920,000
Mica, crude	metric tons	85,200 [r]	10,200 [r]	51,100 [r]	6,530 [r]	52,800	7,240
Peat		647	17,100	644	15,000	605	14,800
Perlite, crude	metric tons	434,000	20,800	348,000	17,100	414,000	21,600
Phosphate rock, marketable[9]		30,200	2,320,000	26,400	3,360,000	25,800	1,980,000
Potash, gross weight[11]		2,400	740,000	1,500	500,000	2,400	660,000
Pumice and pumicite	metric tons	791,000	15,900	410,000	12,300	390,000	7,810
Salt		47,400	1,690,000	43,100	1,750,000	43,500	1,690,000
Sand and gravel:							
Construction		1,060,000	7,890,000 [r]	831,000 [r]	6,240,000 [r]	795,000	5,810,000
Industrial		30,400	937,000 [r]	24,600	783,000	29,900	1,030,000
Soda ash[9]		11,300	1,520,000	9,310	1,330,000	10,600	1,360,000
Stone:							
Crushed[12]		1,460,000	13,600,000	1,160,000 [r]	11,300,000	1,160,000	11,200,000
Dimension		1,800	326,000	1,620	328,000	1,670	323,000
Talc, crude[9]		706	21,800	511	14,600	604	19,100

See footnotes at end of table.

TABLE 1—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral		2008		2009		2010	
		Quantity	Value	Quantity	Value	Quantity	Value
Industrial minerals, excluding fuels[8]—Continued:							
Tripoli[9]	metric tons	132,000	17,100	79,700	16,400	108,000	20,000
Vermiculite, concentrate[e]		100 [13]	W	100 [13]	W	100 [13]	W
Combined values of andalusite, boron minerals, bromine, brucite (2008), clays [fuller's earth (2008–09)], emery (2008–09), greensand marl, iodine (crude), iron oxide pigments (crude), lithium carbonate, magnesite, magnesium compounds, olivine, pyrophyllite (crude), silica stone, staurolite, wollastonite, zeolites, and values indicated by symbol W		XX	1,380,000	XX	963,000 [r]	XX	1,220,000
Total		XX	44,000,000	XX	36,800,000 [r]	XX	36,000,000
Grand total		XX	71,300,000	XX	58,700,000 [r]	XX	66,400,000

[e]Estimated. [r]Revised. do. Ditto. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined values."
XX Not applicable.

[1] Table includes data available through June 6, 2012.

[2] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[3] Data are rounded to no more than three significant digits; may not add to totals shown.

[4] Shipments.

[5] Byproduct from zinc concentrates.

[6] Recoverable content of ores, etc.

[7] Content of ore and concentrate.

[8] Sold or used unless otherwise specified.

[9] Production.

[10] Excludes attapulgite; included in "Combined values."

[11] Data are rounded to two significant digits.

[12] Excludes abrasive stone and bituminous limestone and sandstone; all included elsewhere in table.

[13] Data are rounded to one significant digit.

TABLE 2

NONFUEL MINERALS PRODUCED IN THE UNITED STATES, BY COMMODITY AND STATES IN 2010[1]

(Principal States based on quantity unless otherwise noted)

Mineral	Principal States	Other States (alphabetical order)
Andalusite	NC	
Barite	NV and GA	
Beryllium concentrates	UT	
Boron	CA	
Bromine	AR	
Cement:		
Masonry	IN, TX, FL, AL, CA	AR, AZ, CO, GA, IA, KS, KY, MD, ME, MI, MO, MT, NE, NM, NY, OH, OK, PA, SC, TN, VA, WV.
Portland	TX, CA, MO, MI, PA	All other States, except AK, CT, DE, HI, LA, MA, MN, MS, NC, ND, NH, NJ, RI, VT, WI.
Clays:		
Ball	TN, TX, MS, KY, IN	
Bentonite	WY, UT, MT, AL, TX	AZ, CA, CO, MS, NV, OR.
Common	TX, AL, NC, OH, GA	All other States, except AK, DE, HI, ID, MN, NH, NJ, NV, OR, RI, VT, WI.
Fire	MO, WA, TX, OH	
Fuller's earth	GA, MO, VA, MS, CA	FL, IL, KS, NV, TN, TX.
Kaolin	GA, SC, AL, TX, AR	CA, FL, NC, NV.
Copper[2]	AZ, UT, NV, NM, MT	ID and MO.
Diatomite	CA, NV, OR, WA	
Emery	OR	
Feldspar	NC, VA, OK, CA, ID	GA and SD.
Garnet, industrial	NY, MT, ID	
Gemstones, natural[3]	NC, AZ, OR, UT, CA	All other States.
Gold[2]	NV, AK, UT, CO, WA	AZ, CA, ID, SD.
Greensand marl	NJ	
Gypsum, crude	OK, TX, IA, NV, CA	AR, AZ, CO, IN, KS, KY, LA, MI, NM, SD, UT, WA, WV, WY.
Helium:		
Crude	KS and TX	
Grade–A	KS, WY, TX, OK, CO	UT.
Iodine, crude	OK	
Iron ore, usable	MN, MI, SD, CA	
Iron oxide pigments, crude	GA, AL	
Kyanite	VA	
Lead[2]	AK, MO, ID	
Lime	MO, AL, KY, OH, TX	All other States, except AK, CT, DE, HI, IL, KS, MD, ME, MS, NC, NH, NJ, NY, RI, SC, VT.
Lithium carbonate	NV	
Magnesite	NV	
Magnesium compounds	MI, UT, FL, DE, CA	
Magnesium metal	UT	
Mica, crude	NC, GA, SD, AL	
Molybdenum, concentrates	CO, UT, AZ, ID, MT	NM and NV.
Olivine	NC and WA	
Palladium[2]	MT	
Peat	FL, MN, ME, IL, IN	IA, MI, NJ, NY, OH, PA, WA, WI.
Perlite, crude	NM, OR, AZ, ID, NV	CA.
Phosphate rock	FL, NC, ID, UT	
Platinum[2]	MT	
Potash	NM, UT, MI	
Pumice and pumicite	NV, OR, ID, AZ, CA	NM and KS.
Pyrophyllite, crude	NC and CA	
Salt	LA, TX, NY, OH, KS	AL, AZ, CA, MI, NM, NV, OK, TN, UT, VA, WV.
Sand and gravel:		
Construction	CA, TX, AZ, MI, MN	All other States.
Industrial	IL, TX, WI, MN. OK	All other States, except AK, CT, DE, HI, KY, MA, MD, ME, MS, MT, NH, NM, OR, SD, UT, VT, WY.
Silica stone[4]	AR	

See footnotes at end of table.

TABLE 2—Continued

NONFUEL MINERALS PRODUCED IN THE UNITED STATES, BY COMMODITY AND STATES IN 2010[1]

(Principal States based on quantity unless otherwise noted)

Mineral	Principal States	Other States (alphabetical order)
Silver[2]	AK, NV, ID, UT, AZ	CA, CO, MO, MT, SD.
Soda ash	WY and CA	
Staurolite	FL	
Stone:		
Crushed	TX, PA, MO, IL, KY	All other States.
Dimension	GA, TX, IN, SD, WI	All other States, except AK, DE, FL, HI, IA, KY, LA, MS, ND, NE, NJ, OR, RI.
Talc, crude	MT, TX, VT	
Titanium concentrates, ilmenite	VA and FL	
Tripoli	IL, OK, AR, PA	
Tungsten	CA	
Vermiculite, crude	SC and VA	
Wollastonite	NY	
Zeolites	NM, ID, TX, AZ, CA	NV.
Zinc[2]	AK, TN, MO, ID	
Zirconium concentrates	VA and FL	

[1] Table includes data available through June 6, 2012.

[2] Content of ores, etc.

[3] Principal States based on value.

[4] Grindstones, pulpstones, and sharpening stones; excludes mill liners and grinding pebbles.

TABLE 3

VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2010[1, 2]

State	Value (thousands)	Rank	Percentage of U.S. total	Principal minerals, in order of value
Alabama	969,000	22	1.46	Stone (crushed), cement (portland), lime, sand and gravel (construction), cement (masonry).
Alaska	3,400,000	5	5.13	Zinc, gold, lead, silver, sand and gravel (construction).
Arizona	6,790,000	2	10.24	Copper, molybdenum concentrates, sand and gravel (construction), cement (portland), stone (crushed).
Arkansas	709,000	29	1.07	Bromine, stone (crushed), cement (portland), sand and gravel (construction), lime.
California	2,890,000	6	4.36	Sand and gravel (construction), boron minerals, cement (portland), stone (crushed), gold.
Colorado	1,850,000	12	2.79	Molybdenum concentrates, gold, sand and gravel (construction), cement (portland), stone (crushed).
Connecticut[3]	148,000	43	0.22	Stone (crushed), sand and gravel (construction), clays (common), stone (dimension), gemstones (natural).
Delaware[3]	12,300	50	0.02	Magnesium compounds, sand and gravel (construction), stone (crushed), gemstones (natural).
Florida	2,680,000	8	4.03	Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction), zirconium concentrates.
Georgia	1,430,000	14	2.16	Clays (kaolin), stone (crushed), clays (fuller's earth), cement (portland), sand and gravel (construction).
Hawaii	106,000	46	0.16	Stone (crushed), sand and gravel (construction), gemstones (natural).
Idaho	1,180,000	16	1.78	Molybdenum concentrates, phosphate rock, silver, sand and gravel (construction), lead.
Illinois	924,000	23	1.39	Stone (crushed), sand and gravel (industrial), cement (portland), sand and gravel (construction), tripoli.
Indiana	782,000	26	1.18	Stone (crushed), cement (portland), sand and gravel (construction), lime, stone (dimension).
Iowa	583,000	31	0.88	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), lime.
Kansas	1,090,000	19	1.65	Helium (Grade-A), salt, cement (portland), stone (crushed), helium (crude).
Kentucky	762,000	27	1.15	Stone (crushed), lime, cement (portland), sand and gravel (construction), clays (common).
Louisiana	549,000	32	0.83	Salt, sand and gravel (construction), stone (crushed), sand and gravel (industrial), lime.
Maine	110,000	45	0.17	Sand and gravel (construction), cement (portland), stone (crushed), peat, stone (dimension).
Maryland[3]	305,000	36	0.46	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), stone (dimension).
Massachusetts[3]	233,000	41	0.35	Stone (crushed), sand and gravel (construction), stone (dimension), lime, clays (common).
Michigan	2,190,000	9	3.30	Iron ore (usable shipped), cement (portland), sand and gravel (construction), salt, stone (crushed).
Minnesota[3]	4,180,000	4	6.30	Iron ore (usable shipped), sand and gravel (construction), sand and gravel (industrial), stone (crushed), stone (dimension).
Mississippi	198,000	42	0.30	Sand and gravel (construction), stone (crushed), clays (fuller's earth), clays (ball), clays (bentonite).
Missouri	2,010,000	10	3.03	Stone (crushed), cement (portland), lead, lime, sand and gravel (construction).
Montana	1,140,000	18	1.71	Copper, molybdenum concentrates, palladium metal, platinum metal, sand and gravel (construction).
Nebraska	234,000	40	0.35	Sand and gravel (construction), cement (portland), stone (crushed), sand and gravel (industrial), lime.
Nevada	7,700,000	1	11.61	Gold, copper, silver, lime, sand and gravel (construction).
New Hampshire[3]	93,800	47	0.14	Sand and gravel (construction), stone (crushed), stone (dimension), gemstones (natural).
New Jersey[3]	258,000	39	0.39	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), greensand marl, peat.
New Mexico	1,020,000	21	1.54	Potash, copper, sand and gravel (construction), stone (crushed), cement (portland).
New York	1,310,000	15	1.97	Salt, stone (crushed), sand and gravel (construction), cement (portland), clays (common).
North Carolina	880,000	24	1.33	Stone (crushed), phosphate rock, sand and gravel (construction), sand and gravel (industrial), stone (dimension).
North Dakota[3]	69,900	48	0.11	Sand and gravel (construction), lime, stone (crushed), clays (common), sand and gravel (industrial).
Ohio	1,170,000	17	1.76	Stone (crushed), salt, sand and gravel (construction), lime, cement (portland).
Oklahoma	702,000	30	1.06	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), iodine.
Oregon	312,000	35	0.47	Stone (crushed), sand and gravel (construction), cement (portland), diatomite, perlite (crude).
Pennsylvania[3]	1,670,000	13	2.52	Stone (crushed), cement (portland), lime, sand and gravel (construction), cement (masonry).
Rhode Island[3]	32,900	49	0.05	Sand and gravel (construction), stone (crushed), sand and gravel (industrial), gemstones (natural).
South Carolina[3]	468,000	34	0.71	Stone (crushed), cement (portland), sand and gravel (construction), cement (masonry), sand and gravel (industrial).
South Dakota	258,000	38	0.39	Gold, cement (portland), sand and gravel (construction), stone (crushed), lime.
Tennessee	831,000	25	1.25	Stone (crushed), zinc, cement (portland), sand and gravel (construction), sand and gravel (industrial).
Texas	2,780,000	7	4.19	Stone (crushed), cement (portland), sand and gravel (construction), salt, sand and gravel (industrial).
Utah	4,380,000	3	6.60	Copper, molybdenum concentrates, gold, magnesium metal, potash.
Vermont[3]	121,000	44	0.18	Stone (crushed), sand and gravel (construction), stone (dimension), talc (crude), gemstones (natural).
Virginia	1,040,000	20	1.57	Stone (crushed), sand and gravel (construction), zirconium (concentrates), cement (portland), lime.
Washington	712,000	28	1.07	Gold, sand and gravel (construction), stone (crushed), cement (portland), diatomite.

See footnotes at end of table.

TABLE 3—Continued

VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2010[1, 2]

State	Value (thousands)	Rank	Percentage of U.S. total	Principal minerals, in order of value
West Virginia	272,000	37	0.41	Stone (crushed), cement (portland), lime, sand and gravel (industrial), cement (masonry).
Wisconsin[3]	509,000	33	0.77	Sand and gravel (industrial), sand and gravel (construction), stone (crushed), lime, stone (dimension).
Wyoming	1,860,000	11	2.81	Soda ash, clays (bentonite), helium (Grade-A), sand and gravel (construction), cement (portland).
Undistributed	424,000	XX	0.64	
Total	66,400,000	XX	100.00	

XX Not applicable.

[1] Table includes data available through June 6, 2012.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Partial total; excludes values that must be withheld to avoid disclosing company proprietary data which are included with "Undistributed."

TABLE 4

VALUE OF NONFUEL MINERAL PRODUCTION PER CAPITA AND PER SQUARE KILOMETER IN 2010 BY STATE[1, 2]

State	Land area (square kilometers)	Population (thousands)	Total value (thousands)	Per capita		Per square kilometer	
				Dollars	Rank	Dollars	Rank
Alabama	131,000	4,780	$969,000	$203	16	$7,370	22
Alaska	1,480,000	710	3,400,000	4,790	1	2,300	44
Arizona	294,000	6,390	6,790,000	1,060	6	23,100	2
Arkansas	135,000	2,920	709,000	243	14	5,260	30
California	404,000	37,300	2,890,000	78	40	7,170	23
Colorado	269,000	5,030	1,850,000	369	11	6,900	25
Connecticut	12,500	3,570	148,000 [3]	41	46	11,800	11
Delaware	5,060	898	12,300 [3]	14	50	2,430	43
Florida	140,000	18,800	2,680,000	142	23	19,200	5
Georgia	150,000	9,690	1,430,000	148	21	9,550	17
Hawaii	16,600	1,360	106,000	78	39	6,390	27
Idaho	214,000	1,570	1,180,000	755	8	5,520	29
Illinois	144,000	12,800	924,000	72	41	6,420	26
Indiana	92,900	6,480	782,000	121	29	8,420	18
Iowa	145,000	3,050	583,000	191	18	4,030	38
Kansas	212,000	2,850	1,090,000	383	10	5,160	31
Kentucky	103,000	4,340	762,000	176	20	7,410	21
Louisiana	113,000	4,530	549,000	121	28	4,860	33
Maine	79,900	1,330	110,000	83	37	1,370	46
Maryland	25,300	5,770	305,000 [3]	53	45	12,000	10
Massachusetts	20,300	6,550	233,000 [3]	36	47	11,500	12
Michigan	147,000	9,880	2,190,000	222	15	14,900	6
Minnesota	206,000	5,300	4,180,000 [3]	788	7	20,300	4
Mississippi	121,000	2,970	198,000	67	44	1,630	45
Missouri	178,000	5,990	2,010,000	336	12	11,300	13
Montana	377,000	989	1,140,000	1,150	5	3,010	42
Nebraska	199,000	1,830	234,000	128	27	1,170	49
Nevada	284,000	2,700	7,700,000	2,850	3	27,100	1
New Hampshire	23,200	1,320	93,800 [3]	71	42	4,040	37
New Jersey	19,200	8,790	258,000 [3]	29	49	13,400	8
New Mexico	314,000	2,060	1,020,000	496	9	3,250	41
New York	122,000	19,400	1,310,000	67	43	10,700	15
North Carolina	126,000	9,540	880,000	92	35	6,980	24
North Dakota	179,000	673	69,900 [3]	104	32	391	50
Ohio	106,000	11,500	1,170,000	101	33	11,000	14
Oklahoma	178,000	3,750	702,000	187	19	3,950	39
Oregon	249,000	3,830	312,000	82	38	1,260	48
Pennsylvania	116,000	12,700	1,670,000 [3]	132	24	14,400	7
Rhode Island	2,710	1,050	32,900 [3]	31	48	12,200	9
South Carolina	78,000	4,630	468,000 [3]	101	34	6,000	28
South Dakota	197,000	814	258,000	317	13	1,310	47
Tennessee	107,000	6,350	831,000	131	25	7,790	19
Texas	678,000	25,100	2,780,000	111	30	4,100	36
Utah	213,000	2,760	4,380,000	1,580	4	20,600	3
Vermont	24,000	626	121,000 [3]	194	17	5,060	32
Virginia	103,000	8,000	1,040,000	130	26	10,200	16
Washington	172,000	6,730	712,000	106	31	4,130	35
West Virginia	62,400	1,850	272,000	147	22	4,360	34
Wisconsin	141,000	5,690	509,000 [3]	90	36	3,620	40
Wyoming	251,000	564	1,860,000	3,310	2	7,410	20
Undistributed	XX	XX	424,000	XX	XX	XX	XX
Total or average	9,160,000 [4]	308,000 [4]	66,400,000	215	XX	7,240	XX

See footnotes at end of table.

TABLE 4—Continued

VALUE OF NONFUEL MINERAL PRODUCTION PER CAPITA AND PER SQUARE KILOMETER IN 2010 BY STATE[1, 2]

XX Not applicable.

[1] Table includes data available through June 6, 2012.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Partial total; excludes values that must be concealed to avoid disclosing company proprietary data. Concealed values included with "Undistributed."

[4] Excludes Washington, DC (which has no mineral production), with an area of 179 square kilometers and a population of 601,000.

Sources: U.S. Geological Survey and U.S. Census Bureau.

TABLE 5
NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008 Quantity	2008 Value	2009 Quantity	2009 Value	2010 Quantity	2010 Value
Alabama:						
Cement:						
Masonry	303	38,000 e	208	25,600 e	191	24,300 e
Portland	4,640	450,000 e	3,420	307,000 e	3,290	273,000 e
Clays:						
Common	1,970	34,400	1,340	25,300	1,300	21,500
Kaolin	(4)	W	(4)	W	69	W
Gemstones, natural	NA	398	NA	142 r	NA	7
Lime	2,320	239,000	1,960	226,000 r	2,150	239,000
Sand and gravel:						
Construction	13,800	87,300	10,100 r	65,800 r	10,100	56,200
Industrial	619	14,600	370	11,200	386	10,400
Stone:						
Crushed	50,000	370,000	35,700 r	327,000 r	35,400	331,000
Dimension, marble, sandstone	7	3,720	4	1,460	(4)	W
Combined values of clays (bentonite), iron oxide pigments (crude), mica (crude), salt, and values indicated by symbol W	XX	26,700	XX	26,500	XX	13,800
Total	XX	1,260,000	XX	1,020,000	XX	969,000
Alaska:						
Gemstones, natural	NA	69	NA	69	NA	70
Gold[5] kilograms	(4)	W	(4)	W	28,100	1,110,000
Sand and gravel, construction	11,400	84,800	7,320	55,500	6,340	52,300
Stone, crushed	1,990	31,400	1,940	34,700 r	1,510	22,600
Combined values of cadmium (byproduct from zinc concentrates), lead, silver, zinc, and values indicated by symbol W	XX	2,540,000	XX	2,530,000	XX	2,220,000
Total	XX	2,650,000	XX	2,620,000	XX	3,400,000
Arizona:						
Clays, bentonite	23	1,220	17	913	(4)	W
Copper[5]	836	5,880,000	711	3,780,000	703	5,400,000
Gemstones, natural	NA	1,960	NA	1,540	NA	1,550
Sand and gravel, construction	67,200	562,000	40,200	357,000	35,200	291,000
Stone:						
Crushed	15,300	153,000	9,520 r	88,700 r	8,280	80,300
Dimension, sandstone	123	16,400	94	13,800	81	11,700
Combined values of cement, clays (common), gold, gypsum (crude), lime, molybdenum concentrates, perlite (crude), pumice and pumicite, salt, sand gravel (industrial), silver, zeolites, and value indicated by symbol W	XX	1,230,000	XX	946,000 r	XX	1,010,000
Total	XX	7,850,000	XX	5,190,000 r	XX	6,790,000
Arkansas:						
Clays, common	796	10,700	539	7,630	534	7,580
Gemstones, natural	NA	607	NA	410	NA	424
Sand and gravel, construction	8,800	65,100	7,780 r	60,000 r	9,050	76,800
Stone:						
Crushed	32,200	241,000	29,400 r	215,000 r	31,000	238,000
Dimension	21	2,740	18	2,360	11	1,570

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

	2008		2009		2010	
Mineral	Quantity	Value	Quantity	Value	Quantity	Value
Arkansas—Continued:						
Combined values of bromine, cement, clays (kaolin), gypsum (crude), lime, sand and gravel (industrial), silica stone, tripoli	XX	390,000	XX	336,000 [r]	XX	385,000
Total	XX	710,000	XX	621,000 [r]	XX	709,000
California:						
Cement:						
Masonry	337	43,600 [e]	236	28,100 [e]	178	19,500 [e]
Portland	9,880	1,030,000 [e]	7,150	646,000 [e]	6,950	549,000 [e]
Clays:						
Bentonite	30	3,360	22	2,310	23	2,700
Common	469	3,570	318	2,370	355	5,000
Fire	118	W	(4)	W	--	--
Kaolin	(4)	W	(4)	W	7	W
Gemstones, natural	NA	732	NA	727	NA	754
Gypsum, crude	(4)	W	1,210 [r]	8,980 [r]	(4)	W
Sand and gravel:						
Construction	111,000	1,260,000	79,200	912,000	74,700	809,000
Industrial	1,500	42,300	1,300	35,800	1,320	39,400
Stone:						
Crushed	51,400	572,000	39,800 [r]	377,000 [r]	31,700	313,000
Dimension	26	7,320	24 [r]	6,100	26	6,940
Combined values of boron minerals, clays (fuller's earth) diatomite, feldspar, gold, iron ore (usable shipped), lime, magnesium compounds, perlite (crude), pumice and pumicite, pyrophyllite (2009–10), salt, silver, soda ash, talc [crude (2008)], tungsten, zeolites, and values indicated by symbol W	XX	1,250,000 [r]	XX	888,000 [r]	XX	1,150,000
Total	XX	4,200,000	XX	2,910,000 [r]	XX	2,890,000
Colorado:						
Clays:						
Bentonite	2	40	1	30	(4)	W
Common	141	644	60	405	109	342
Gemstones, natural	NA	419	NA	426	NA	431
Sand and gravel, construction	37,800	299,000	29,300	217,000	28,900	209,000
Stone:						
Crushed	9,590	71,300	6,800 [r]	62,200 [r]	7,320	58,400
Dimension	27	4,510	11	3,110	8	1,740
Combined values of cement, clays [fire (2009)], gold, gypsum (crude), helium (Grade–A), lime, molybdenum concentrates, sand and gravel (industrial), silver, and value indicated by symbol W	XX	1,680,000	XX	1,130,000	XX	1,580,000
Total	XX	2,060,000	XX	1,420,000	XX	1,850,000
Connecticut:						
Clays, common	(4)	(6)	20	224	(4)	(6)
Gemstones, natural	NA	7	NA	7	NA	7
Sand and gravel, construction	7,350	69,600	5,680	60,800	5,910	55,300
Stone:						
Crushed	9,640	106,000	8,160 [r]	102,000 [r]	7,250	92,700
Dimension	(4)	(6)	(4)	(6)	(4)	(6)
Total	XX	175,000	XX	163,000 [r]	XX	148,000

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008		2009		2010	
	Quantity	Value	Quantity	Value	Quantity	Value
Delaware:						
Gemstones, natural	NA	1	NA	1	NA	1
Magnesium compounds	(4)	(6)	(4)	(6)	(4)	(6)
Sand and gravel, construction	2,550	20,600	2,080	24,500	1,620	12,300
Stone, crushed	(4)	(6)	(4)	(6)	(4)	(6)
Total	XX	20,600	XX	24,500	XX	12,300
Florida:						
Cement:						
Masonry	310	47,000[e]	123	18,700[e]	198	26,100[e]
Portland	4,980	518,000[e]	3,150	307,000[e]	3,350	304,000[e]
Clays:						
Common	2	W	(4)	W	2	W
Kaolin	19	2,520	18	3,000	15	W
Gemstones, natural	NA	1	NA	2[r]	NA	1
Peat	488	9,760	527	10,100	480	9,710
Sand and gravel:						
Construction	28,200	219,000	15,500[r]	124,000[r]	12,500	98,900
Industrial	573	7,480	431	8,270	173	3,980
Stone, crushed	68,400	894,000	41,200[r]	558,000[r]	42,800	548,000
Combined values of clays (fuller's earth), lime, magnesium compounds, phosphate rock, staurolite, titanium concentrates (ilmenite), zirconium concentrates, and values indicated by symbol W	XX	2,040,000	XX	3,130,000	XX	1,690,000
Total	XX	3,730,000	XX	4,160,000[r]	XX	2,680,000
Georgia:						
Barite	7	1,350	7	1,350	7	1,350
Clays:						
Common	952	6,020	631	3,870	657	3,910
Fuller's earth	646[7]	51,800[7]	(4)	W	(4)	W
Kaolin	6,290	872,000	4,970	693,000	5,050	757,000
Gemstones, natural	NA	74	NA	74	NA	75
Sand and gravel:						
Construction	7,360	40,300	5,260	31,100	5,120	28,400
Industrial	841	20,700	775	19,300	670	17,800
Stone:						
Crushed	61,900	666,000	44,500[r]	510,000[r]	42,900	466,000
Dimension	169	18,200	153	16,900	264	25,500
Combined values of cement, feldspar, iron oxide pigments (crude), lime, mica (crude), and values indicated by symbol W	XX	112,000[r]	XX	129,000[r]	XX	132,000
Total	XX	1,790,000	XX	1,400,000[r]	XX	1,430,000
Hawaii:						
Gemstones, natural	NA	151	NA	151	NA	151
Sand and gravel, construction	1,640	29,800	1,130	14,300	932	14,200
Stone, crushed	7,410	134,000	5,800[r]	101,000	4,750	91,900
Total	XX	164,000	XX	115,000[r]	XX	106,000
Idaho:						
Gemstones, natural	NA	430	NA	492[r]	NA	430
Sand and gravel, construction	18,800	107,000	12,900	74,800[r]	13,700	78,200
Stone:						
Crushed	5,950	38,800	3,880[r]	26,600[r]	4,030	23,900
Dimension, quartzite, sandstone	34	4,130	25	3,370	25	3,520

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008		2009		2010	
	Quantity	Value	Quantity	Value	Quantity	Value
Idaho—Continued:						
Combined values of cadmium (byproduct from zinc concentrates), cement (portland), copper, feldspar, garnet (industrial), gold, lead, lime, molybdenum concentrates, perlite (crude), phosphate rock, pumice and pumicite, sand and gravel (industrial), silver, zeolites, zinc	XX	921,000	XX	825,000 r	XX	1,080,000
Total	XX	1,070,000	XX	931,000 r	XX	1,180,000
Illinois:						
Cement, portland	2,660	263,000 e	1,490	141,000 e	1,620	144,000 e
Clays, fuller's earth	112	W	(4)	W	(4)	W
Gemstones, natural	NA	10	NA	10 r	NA	10
Sand and gravel:						
Construction	27,000	168,000	22,500	144,000	19,400	128,000
Industrial	3,980	108,000	3,440	104,000	4,370	148,000
Stone, crushed	67,200 r	610,000 r	56,900 r	514,000 r	53,100	477,000
Combined values of clays (common), lime (2008), peat, stone (dimension dolomite), tripoli, and values indicated by symbol W	XX	60,900	XX	26,900	XX	27,400
Total	XX	1,210,000	XX	930,000 r	XX	924,000
Indiana:						
Cement, portland	2,590	226,000 e	2,690	233,000 e	2,470	199,000 e
Clays, common	667	8,080	413	6,610	358	7,110
Gemstones, natural	NA	4	NA	4	NA	4
Sand and gravel, construction	23,400 r	141,000 r	18,800	100,000	18,600	115,000
Stone:						
Crushed	51,800	352,000	44,200 r	290,000	44,300	291,000
Dimension	203	35,600	206	41,500	173	31,400
Combined values of cement (masonry), clays (ball), gypsum (crude), lime, peat, sand and gravel (industrial)	XX	131,000	XX	133,000 r	XX	139,000
Total	XX	894,000 r	XX	804,000 r	XX	782,000
Iowa:						
Clays, common	269	1,140	184	828	201	828
Gemstones, natural	NA	3	NA	3	NA	3
Gypsum, crude	1,250	9,230	(4)	W	(4)	W
Sand and gravel, construction	15,800	89,500	13,600	87,800 r	13,800	84,800
Stone, crushed	38,700	312,000	32,700 r	298,000 r	31,800	292,000
Combined values of cement, lime, peat, sand and gravel (industrial), and values indicated by symbol W	XX	268,000	XX	205,000 r	XX	205,000
Total	XX	680,000	XX	592,000 r	XX	583,000
Kansas:						
Cement, portland	2,400	246,000 e	1,670	170,000 e	1,820	178,000 e
Clays, common	548	2,840	381	2,430	353	1,850
Gemstones, natural	NA	1	NA	1	NA	1
Helium, Grade-A million cubic meters	79	384,000	68	332,000	78	421,000
Salt	3,010	178,000	2,710	188,000	3,080	194,000
Sand and gravel, construction	10,500	51,600	8,580	43,300	9,610	50,300
Stone:						
Crushed	23,100	180,000	16,900 r	142,000 r	16,800	143,000
Dimension	20	2,560	29	4,650	47	4,720

See footnotes at end of table.

TABLE 5—Continued
NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008		2009		2010	
	Quantity	Value	Quantity	Value	Quantity	Value
Kansas—Continued:						
Combined values of cement (masonry), clays (fuller's earth), gypsum (crude), helium (crude), pumice and pumicite, sand and gravel (industrial)	XX	77,500	XX	68,600 [r]	XX	100,000
Total	XX	1,120,000	XX	950,000 [r]	XX	1,090,000
Kentucky:						
Clays, common	419	8,170	288	5,980	284	5,780
Gemstones, natural	NA	173	NA	37	NA	12
Sand and gravel, construction	7,620	41,700	6,770 [r]	36,000 [r]	5,740	30,000
Stone, crushed	52,700	422,000	47,000 [r]	415,000 [r]	49,200	425,000
Combined values of cement, clays (ball), gypsum [crude (2009–10)], lime	XX	324,000	XX	245,000 [r]	XX	301,000
Total	XX	796,000	XX	702,000 [r]	XX	762,000
Louisiana:						
Clays, common	509	12,900	353	9,120	151	1,340
Gemstones, natural	NA	7	NA	7	NA	7
Salt	14,600	231,000	13,200	229,000	14,100	234,000
Sand and gravel:						
Construction	22,900	231,000	20,600	205,000	20,800	190,000
Industrial	748	23,100	682	25,900	629	25,600
Combined values of gypsum (crude), lime, stone (crushed limestone and sandstone)	XX	123,000	XX	102,000 [r]	XX	97,600
Total	XX	620,000	XX	570,000 [r]	XX	549,000
Maine:						
Gemstones, natural	NA	282	NA	353 [r]	NA	347
Sand and gravel, construction	10,200	69,400 [r]	9,090	59,300	7,840	45,100
Stone:						
Crushed	4,020	33,900	3,600	31,600	3,430	30,200
Dimension	7	1,720	6	1,300	8	1,250
Combined values of cement, clays (common), peat	XX	56,000	XX	32,600	XX	32,900
Total	XX	161,000	XX	125,000	XX	110,000
Maryland:						
Gemstones, natural	NA	1	NA	1	NA	1
Sand and gravel, construction	12,000	125,000 [r]	7,980	99,200	8,120	82,700
Stone:						
Crushed	26,100	237,000	23,300 [r]	208,000 [r]	21,700	221,000
Dimension	(4)	W	(4)	W	8	1,630
Combined values of cement, clays (common), sand and gravel [industrial (2008)], and values indicated by symbol W	XX	279,000	XX	198,000	XX	(6)
Total	XX	641,000 [r]	XX	505,000 [r]	XX	305,000
Massachusetts:						
Clays, common	24	(6)	(4)	(6)	17	(6)
Gemstones, natural	NA	1	NA	1	NA	1
Lime	(4)	(6)	(4)	(6)	(4)	(6)
Sand and gravel, construction	10,800 [r]	103,000 [r]	9,460	85,600	9,700	91,400
Stone:						
Crushed	11,200	130,000	11,200 [r]	130,000 [r]	10,400	120,000
Dimension	53	7,140	44	6,130	73	21,700
Total	XX	240,000 [r]	XX	221,000 [r]	XX	233,000

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008		2009		2010	
	Quantity	Value	Quantity	Value	Quantity	Value
Michigan:						
Cement:						
Masonry	99	12,000 [e]	80	9,800 [e]	83	10,200 [e]
Portland	4,930	502,000 [e]	3,550	350,000 [e]	3,480	350,000 [e]
Clays, common	365	1,730	318	1,310	312	1,280
Gemstones, natural	NA	2	NA	2	NA	2
Gypsum, crude	603	4,490	420 [r]	3,130 [r]	(4)	W
Iron ore, usable shipped	12,500	W	8,870	W	11,900	W
Peat	(4)	W	(4)	W	4	W
Sand and gravel:						
Construction	45,100	211,000	34,600	176,000	33,600	192,000
Industrial	1,500	26,800	1,330	27,700	1,260	27,300
Stone, crushed	26,100	136,000	20,400	116,000 [r]	21,900	122,000
Combined values of lime, magnesium compounds, potash, salt, stone (dimension dolomite sandstone), and values indicated by symbol W	XX	1,130,000	XX	1,080,000	XX	1,490,000
Total	XX	2,020,000	XX	1,760,000	XX	2,190,000
Minnesota:						
Gemstones, natural	NA	7	NA	7	NA	7
Iron ore, usable shipped	41,100	W	18,700	W	38,800	3,810,000
Peat	48	4,540	44	2,850	41	2,500
Sand and gravel:						
Construction	34,700	227,000	31,300 [r]	191,000 [r]	32,300	158,000
Industrial	(4)	W	(4)	W	1,940	100,000
Stone:						
Crushed	10,300	122,000	7,440 [r]	92,300 [r]	7,350	90,200
Dimension	31	17,200	25	16,700	35	15,400
Combined values of clays [common (2008)], lime, and values indicated by symbol W	XX	3,090,000	XX	1,830,000	XX	(6)
Total	XX	3,460,000	XX	2,140,000 [r]	XX	4,180,000
Mississippi:						
Clays:						
Bentonite	53	3,690	(4)	W	(4)	W
Common	433	2,340	263	1,540	259	1,540
Fuller's earth	384	W	(4)	W	(4)	W
Gemstones, natural	NA	1	NA	1	NA	1
Sand and gravel, construction	12,800	91,400	12,700	101,000	12,500	97,100
Stone, crushed	4,380	88,800	3,130	63,400	2,910	65,500
Combined values of cement (portland), clays (ball), sand and gravel [industrial (2008–09)], and values indicated by symbol W	XX	77,200	XX	42,200	XX	34,100
Total	XX	263,000	XX	208,000	XX	198,000
Missouri:						
Cement, portland	4,650	451,000 [e]	4,420	434,000 [e]	6,470	534,000 [e]
Clays, common	496	3,470	421	3,020	412	3,060
Sand and gravel:						
Construction	12,400	76,200	11,500	71,900	11,800	73,200
Industrial	648	21,400	763	28,900	608	20,000
Stone, crushed	76,400	614,000	72,800 [r]	639,000 [r]	70,200	595,000

See footnotes at end of table.

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008		2009		2010	
	Quantity	Value	Quantity	Value	Quantity	Value
Missouri—Continued:						
Combined values of cadmium (byproduct from zinc concentrates), cement (masonry), clays (fire, fuller's earth), copper, gemstones (natural), lead, lime, silver, stone (dimension granite), tripoli (2010), zinc	XX	892,000	XX	661,000 r	XX	785,000
Total	XX	2,060,000	XX	1,840,000 r	XX	2,010,000
Montana:						
Gemstones, natural	NA	380	NA	378	NA	515
Palladium[5] kilograms	11,900	136,000	12,700	108,000	11,600	199,000
Platinum[5] do.	3,580	182,000	3,830	149,000	3,450	179,000
Sand and gravel, construction	13,400	110,000	11,200	86,000 r	10,100	81,800
Stone:						
Crushed	1,990 r	14,000	1,990	20,400	2,020	21,200
Dimension	(4)	W	(4)	W	11	2,950
Combined values of cadmium [byproduct from zinc concentrates (2008–09)], cement, clays (bentonite, common), copper, garnet (industrial), gold (2008–09), lead (2008–09), lime, molybdenum concentrates, silver, talc (crude), zinc (2008–09), and values indicated by symbol W	XX	924,000	XX	619,000	XX	652,000
Total	XX	1,370,000	XX	983,000 r	XX	1,140,000
Nebraska:						
Clays, common	109	W	(4)	W	(4)	W
Gemstones, natural	NA	4	NA	4	NA	4
Sand and gravel, construction	14,000	75,400	12,900	75,500	12,500	79,900
Stone, crushed	7,960	78,100	6,200 r	59,200 r	6,760	70,100
Combined values of cement, lime, sand and gravel [industrial (2009–10)], and values indicated by symbol W	XX	(6)	XX	113,000	XX	83,600
Total	XX	153,000	XX	248,000	XX	234,000
Nevada:						
Barite	641	29,500	377	18,500	656	35,900
Clays, kaolin	(4)	W	(4)	W	19	W
Gold[5] kilograms	178,000	5,000,000	161,000	5,040,000	166,000	6,560,000
Sand and gravel, construction	29,500	163,000	19,800 r	124,000 r	15,100	87,500
Silver[5] kilograms	235,000	113,000	203,000	95,900	224,000	145,000
Stone, crushed	10,200	95,100	7,380 r	81,300 r	6,970	80,800
Combined values of cement (portland), clays (bentonite, fuller's earth), copper, diatomite, gemstones (natural), gypsum (crude), lime, lithium carbonate, magnesite, molybdenum concentrates, perlite (crude), pumice and pumicite, salt, sand and gravel (industrial), stone (dimension), zeolites, and values indicated by symbol W	XX	893,000	XX	641,000 r	XX	791,000
Total	XX	6,290,000	XX	6,000,000 r	XX	7,700,000
New Hampshire:						
Gemstones, natural	NA	7	NA	7	NA	7
Sand and gravel, construction	8,150	51,200	6,930	55,600	6,390	54,300
Stone:						
Crushed	5,170	50,900	4,800 r	47,600 r	4,320	39,500
Dimension, granite	34	4,900	35	4,880	(4)	(6)
Total	XX	107,000	XX	108,000	XX	93,800

See footnotes at end of table.

TABLE 5—Continued
NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008 Quantity	2008 Value	2009 Quantity	2009 Value	2010 Quantity	2010 Value
New Jersey:						
Gemstones, natural	NA	1	NA	1	NA	1
Greensand marl	(4)	(6)	(4)	(6)	(4)	(6)
Peat	(4)	(6)	(4)	(6)	(4)	(6)
Sand and gravel:						
Construction	13,600	153,000	11,100	116,000	10,000	105,000
Industrial	1,010	31,800	906	30,200	918	33,600
Stone, crushed	17,900	155,000	14,500	124,000	14,400	119,000
Total	XX	339,000	XX	270,000	XX	258,000
New Mexico:						
Clays, common	14	120	10	90	13	116
Copper[5]	104	734,000	56	300,000	53	405,000
Gemstones, natural	NA	21	NA	21	NA	15
Sand and gravel, construction	14,600	127,000	14,100 r	111,000 r	11,600	84,400
Stone:						
Crushed	7,020	43,400	6,000 r	39,400 r	4,280	34,100
Dimension	27	939	32	986	(4)	W
Combined values of cement, gold (2008–09), gypsum (crude), helium [Grade-A (2008–09)], lime (2008, 2010), molybdenum concentrates, perlite (crude), potash, pumice and pumicite, salt, sand and gravel [industrial (2008)], silver (2008–09), zeolites, and value indicated by symbol W	XX	720,000	XX	428,000 r	XX	498,000
Total	XX	1,630,000	XX	879,000 r	XX	1,020,000
New York:						
Clays, common	745	28,200	605	30,200	595	30,000
Gemstones, natural	NA	96	NA	97	NA	97
Salt	7,660	431,000	6,240	426,000	6,460	442,000
Sand and gravel, construction	34,400	260,000	31,100	266,000	30,600	248,000
Stone:						
Crushed	41,000	384,000	38,000 r	431,000 r	33,000	367,000
Dimension	57	16,000	97	28,200	96	26,000
Combined values of cadmium [byproduct from zinc concentrates (2008)], cement, garnet (industrial), peat, sand and gravel (industrial), talc [crude (2008)], wollastonite, zinc (2008)	XX	354,000	XX	207,000	XX	193,000
Total	XX	1,470,000	XX	1,390,000 r	XX	1,310,000
North Carolina:						
Clays:						
Common	1,260	12,900	828	4,980	846	4,890
Kaolin	15	W	(4)	W	10	W
Gemstones, natural	NA	659	NA	1,260 r	NA	1,950
Mica, crude	22	4,460 r	(4)	W	(4)	W
Sand and gravel:						
Construction	9,770	58,800	7,570	43,000	8,130	45,700
Industrial	1,510	29,400	1,300	28,000	1,400	30,900
Stone:						
Crushed	57,500	806,000	38,700 r	587,000 r	40,500	591,000
Dimension	58	25,200	62	22,300	63	21,800

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008		2009		2010	
	Quantity	Value	Quantity	Value	Quantity	Value
North Carolina—Continued:						
Combined values of andalusite, feldspar, olivine, phosphate rock, pyrophyllite (crude), and values indicated by symbol W	XX	150,000	XX	163,000 ^{r}	XX	183,000
Total	XX	1,090,000	XX	850,000 ^{r}	XX	880,000
North Dakota:						
Clays, common	84	549	(4)	(6)	(4)	(6)
Gemstones, natural	NA	4	NA	4	NA	4
Lime	(4)	(6)	(4)	(6)	(4)	(6)
Sand and gravel:						
Construction	12,100	39,200	14,300 ^{r}	46,500 ^{r}	17,000	66,100
Industrial	(4)	(6)	(4)	(6)	(4)	(6)
Stone, crushed	26	133	985	3,980	835	3,770
Total	XX	39,800	XX	50,400 ^{r}	XX	69,900
Ohio:						
Cement, portland	762	74,000 ^{e}	550	53,000 ^{e}	627	57,800 ^{e}
Clays, common	983	15,900	770	13,400	815	14,600
Gemstones, natural	NA	4	NA	4	NA	4
Lime	1,670	166,000	1,130	129,000	1,610	164,000
Sand and gravel:						
Construction	33,800	244,000	27,200	199,000 ^{r}	29,900	232,000
Industrial	1,010	34,300	849	26,300	821	27,800
Stone:						
Crushed	54,100	446,000	43,300 ^{r}	395,000 ^{r}	47,200	394,000
Dimension	29	3,660	26	4,790	25	4,440
Combined values of cement (masonry), clays (fire), peat, salt	XX	262,000	XX	277,000	XX	274,000
Total	XX	1,250,000	XX	1,100,000 ^{r}	XX	1,170,000
Oklahoma:						
Clays, common	756	3,900	572	2,800	554	2,600
Gemstones, natural	NA	4	NA	4	NA	4
Gypsum, crude	2,180	16,200	(4)	W	(4)	W
Sand and gravel:						
Construction	14,700	95,500	11,600	68,200	10,000	60,500
Industrial	2,040	63,700	1,410	40,300	1,900	57,200
Stone:						
Crushed	46,800 ^{r}	342,000 ^{r}	36,100 ^{r}	301,000 ^{r}	39,000	343,000
Dimension	53	8,750	35	4,330	30	2,750
Combined values of cement, feldspar, helium (Grade–A), iodine (crude), lime, salt, tripoli (2008–09), and values indicated by symbol W	XX	287,000 ^{r}	XX	240,000 ^{r}	XX	236,000
Total	XX	817,000 ^{r}	XX	657,000 ^{r}	XX	702,000
Oregon:						
Gemstones, natural	NA	1,620	NA	1,220	NA	1,050
Sand and gravel, construction	14,900	121,000	12,200	102,000	11,400	93,000
Stone, crushed	23,500	174,000	15,500 ^{r}	118,000 ^{r}	16,300	122,000
Combine values of cement (portland), clays [bentonite, common (2008)], diatomite, emery, lime, perlite (crude), pumice and pumicite	XX	106,000	XX	91,500	XX	96,400
Total	XX	402,000	XX	313,000 ^{r}	XX	312,000

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008		2009		2010	
	Quantity	Value	Quantity	Value	Quantity	Value
Pennsylvania:						
Cement:						
Masonry	254	34,000 ^{e}	176	23,700 ^{e}	147	17,700 ^{e}
Portland	5,150	510,000 ^{e}	3,720 ^{r}	354,000 $^{r, e}$	3,380	321,000 ^{e}
Clays, common	640	4,840	451	3,040	344	2,490
Gemstones, natural	NA	1	NA	1	NA	1
Lime	1,130	126,000	985	126,000	1,110	145,000
Peat	2	62	3	90	2	58
Sand and gravel:						
Construction	16,100	132,000	14,000 ^{r}	115,000 ^{r}	13,400	118,000
Industrial	677	16,300	618	15,600	524	13,400
Stone:						
Crushed	101,000	1,140,000	81,500 ^{r}	1,000,000 ^{r}	85,500	1,050,000
Dimension	42	11,100	39	9,670	25	5,860
Tripoli	(4)	(6)	(4)	(6)	(4)	(6)
Total	XX	1,970,000	XX	1,650,000 ^{r}	XX	1,670,000
Rhode Island:						
Gemstones, natural	NA	1	NA	1	NA	1
Sand and gravel:						
Construction	2,000	27,400	1,820	23,300	1,450	17,100
Industrial	(4)	(6)	(4)	(6)	(4)	(6)
Stone, crushed	1,840	17,900	1,820	20,200	1,440	15,800
Total	XX	45,300	XX	43,400	XX	32,900
South Carolina:						
Cement:						
Masonry	323	41,600 ^{e}	174	22,000 ^{e}	152	18,300 ^{e}
Portland	2,930	284,000 ^{e}	1,870	169,000 ^{e}	2,050	178,000 ^{e}
Clays:						
Common	461	2,130	311	1,300	267	1,190
Fire	29	66	--	--	--	--
Kaolin	199	11,300	144	8,590	158	10,500
Gemstones, natural	NA	1	NA	1	NA	1
Mica, crude	(4)	(6)	--	--	--	--
Sand and gravel:						
Construction	9,660	46,500	5,900	32,900	7,100	30,200
Industrial	679	21,100	441	14,000	530	14,700
Stone:						
Crushed	22,500	235,000	18,200	201,000	19,200	215,000
Dimension	4	472	3	401	(4)	(6)
Vermiculite	(4)	(6)	(4)	(6)	(4)	(6)
Total	XX	642,000	XX	449,000	XX	468,000
South Dakota:						
Clays, common	155	W	(4)	W	(4)	W
Sand and gravel, construction	12,500	48,000	10,600 ^{r}	38,000 ^{r}	10,500	44,300
Stone, crushed	5,390	34,300	4,540 ^{r}	29,900 ^{r}	4,890	32,200
Combined values of cement (portland), feldspar, gemstones (natural), gold, gypsum (crude), iron ore (usable shipped), lime, mica (crude), silver (2009–10), stone (dimension granite), and values indicated by symbol W	XX	165,000	XX	163,000 ^{r}	XX	182,000
Total	XX	247,000	XX	231,000 ^{r}	XX	258,000

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008 Quantity	2008 Value	2009 Quantity	2009 Value	2010 Quantity	2010 Value
Tennessee:						
Clays:						
Ball	568	25,900	511	22,800	570	25,600
Common	155	1,090	113 r	816	113	817
Sand and gravel:						
Construction	7,180	56,200	5,360	42,800	5,900	47,000
Industrial	983	32,800	783	27,100	907	30,500
Stone, crushed	46,200	461,000	40,300 r	453,000 r	40,900	464,000
Combined values of cadmium (byproduct from zinc concentrates), cement, clays (fuller's earth), gemstones (natural), lime, salt, stone (dimension marble), zinc	XX	281,000	XX	150,000	XX	263,000
Total	XX	859,000	XX	697,000 r	XX	831,000
Texas:						
Cement:						
Masonry	274	40,300 e	202	28,300 e	199	26,800 e
Portland	11,100	1,110,000 e	8,350	815,000 e	8,870	785,000 e
Clays:						
Bentonite	73	12,000	54	8,610	64	9,900
Common	2,070	13,700	1,800	13,000	1,740	14,000
Kaolin	(4)	W	(4)	W	47	13,900
Gemstones, natural	NA	202	NA	202	NA	203
Gypsum, crude	1,870	13,900	(4)	W	(4)	W
Lime	1,500	128,000	1,040	105,000	1,280	136,000
Salt	9,080	157,000	8,910	164,000	9,130	173,000
Sand and gravel:						
Construction	88,200 r	632,000 r	70,000	527,000 r	69,500	525,000
Industrial	3,590	139,000	2,130	84,400	3,610	162,000
Stone:						
Crushed	150,000	1,100,000	110,000	788,000 r	114,000	807,000
Dimension	269	27,700	236	42,000	195	57,000
Combined values of brucite (2008), clays [ball, fire (2009–10)], fuller's earth], helium, talc (crude), zeolites, and values indicated by symbol W	XX	77,700	XX	78,400 r	XX	72,100
Total	XX	3,450,000	XX	2,650,000	XX	2,780,000
Utah:						
Beryllium concentrates metric tons	4,410	NA	3,030	NA	4,460	NA
Clays, common	479	10,200	342	7,230	322	7,020
Gemstones, natural	NA	781	NA	783	NA	786
Salt	2,150	139,000	2,000	152,000	1,940	100,000
Sand and gravel, construction	38,900	222,000	32,400	190,000	25,700	148,000
Stone:						
Crushed	8,950	72,700	4,790 r	39,100 r	5,840	43,800
Dimension, sandstone	9	707	9	844	9	674
Combined values of cement (portland), clays (bentonite), copper, gold, gypsum (crude), helium (Grade–A), lime, magnesium compounds, magnesium metal, molybdenum concentrates, phosphate rock, potash, silver	XX	3,730,000	XX	3,520,000 r	XX	4,080,000
Total	XX	4,170,000	XX	3,910,000 r	XX	4,380,000
Vermont:						
Gemstones, natural	NA	1	NA	1	NA	1
Sand and gravel, construction	4,960	33,600	4,470	36,700	4,770	35,200

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008 Quantity	2008 Value	2009 Quantity	2009 Value	2010 Quantity	2010 Value
Vermont—Continued:						
Stone:						
Crushed	5,690	47,500	5,480 [r]	55,900 [r]	6,080	64,100
Dimension	112	35,900	108	30,000	68	21,900
Talc, crude	(4)	(6)	(4)	(6)	(4)	(6)
Total	XX	117,000	XX	123,000 [r]	XX	121,000
Virginia:						
Clays, common	766	8,540	505	5,830	503	6,010
Kyanite	97	25,500	71	21,000 [r]	93	28,000
Sand and gravel, construction	10,400	111,000	7,230 [r]	82,200 [r]	7,690	88,200
Stone:						
Crushed	57,400	712,000	42,300 [r]	580,000 [r]	44,100	613,000
Dimension	(4)	W	(4)	W	14	3,920
Combined values of cement, clays (fuller's earth), feldspar, gemstones (natural), iron oxide pigments [crude (2008–09)], lime, salt, sand and gravel (industrial), titanium concentrates (ilmenite), vermiculite (crude), zirconium concentrates, and values indicated by symbol W	XX	318,000	XX	260,000	XX	303,000
Total	XX	1,170,000	XX	949,000 [r]	XX	1,040,000
Washington:						
Clays, common	88	360	(4)	W	(4)	W
Gemstones, natural	NA	50	NA	65	NA	64
Gypsum, crude	--	--	101	757	(4)	W
Peat	(4)	75	(4)	W	(4)	W
Sand and gravel, construction	39,500 [r]	325,000 [r]	29,900	230,000	27,200	188,000
Stone, crushed	17,500	168,000	14,800 [r]	132,000 [r]	14,800	133,000
Combined values of cadmium [byproduct from zinc concentrates (2008–09)], cement (portland), clays [fire (2009–10)], diatomite, gold, lead (2008–09), lime, olivine, sand and gravel (industrial), stone (dimension miscellaneous), zinc (2008–09), and values indicated by symbol W	XX	228,000	XX	289,000	XX	391,000
Total	XX	722,000	XX	651,000 [r]	XX	712,000
West Virginia:						
Clays, common	(4)	W	(4)	W	138	200
Gemstones, natural	NA	1	NA	1	NA	1
Gypsum, crude	--	--	119	889	(4)	W
Sand and gravel:						
Construction	426	3,840	410	3,480	448	3,740
Industrial	338	17,200	241	14,700	277	17,300
Stone, crushed	15,200	127,000	12,300 [r]	112,000 [r]	14,700	141,000
Combined values of cement, lime, salt, stone (dimension sandstone), and values indicated by symbol W	XX	85,300	XX	71,600	XX	109,000
Total	XX	234,000	XX	202,000 [r]	XX	272,000
Wisconsin:						
Gemstones, natural	NA	7	NA	7	NA	7
Lime	852	71,500	750 [r]	70,000 [r]	867	81,200
Peat	(4)	26	--	--	(4)	W

See footnotes at end of table.

TABLE 5—Continued

NONFUEL MINERAL PRODUCTION IN THE UNITED STATES, BY STATE[1, 2, 3]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2008		2009		2010	
	Quantity	Value	Quantity	Value	Quantity	Value
Wisconsin—Continued:						
Sand and gravel:						
Construction	36,200	190,000	28,300 [r]	139,000 [r]	26,000	133,000
Industrial	3,290	120,000	2,730	105,000	3,390	142,000
Stone:						
Crushed	25,900	238,000	23,100 [r]	179,000 [r]	22,600	130,000
Dimension	250	33,300	207	29,800	144	23,200
Total	XX	652,000	XX	523,000 [r]	XX	509,000
Wyoming:						
Clays:						
Bentonite	4,400	233,000	3,230	172,000	4,150	225,000
Common	37	89	41	104	12	33
Gemstones, natural	NA	14	NA	14	NA	14
Sand and gravel, construction	17,500	103,000	17,200	92,200	14,300	71,500
Stone, crushed	12,100	57,100	16,000	75,400	8,910	40,300
Combined values of cement (portland), gypsum (crude), helium (Grade–A), lime, soda ash, stone (dimension)	XX	1,640,000	XX	1,460,000	XX	1,530,000
Total	XX	2,030,000	XX	1,800,000	XX	1,860,000
Undistributed:						
Connecticut, Delaware, Maryland (2010), Massachusetts, Minnesota (2010), Nebraska (2008), New Hampshire (2010), New Jersey, North Dakota, Pennsylvania, Rhode Island, South Carolina, Vermont, Wisconsin (2008, 2010), Undistributed	XX	167,000	XX	89,500	XX	424,000

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Combined values" data for each State. XX Not applicable. -- Zero.

[1] Table includes data available through June 6, 2012.

[2] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[3] Data are rounded to no more than three significant digits; may not add to totals shown.

[4] Withheld to avoid disclosing company proprietary data.

[5] Recoverable content of ores, etc.

[6] Withheld to avoid disclosing company proprietary data; value included in "Undistributed."

[7] Excludes attapulgite; included in "Combined values."

TABLE 6
NONFUEL RAW MINERAL PRODUCTION IN THE COMMONWEALTH OF PUERTO RICO AND ISLANDS ADMINISTERED BY THE UNITED STATES[1, 2, 3]

(Thousand metric tons and thousand dollars)

Mineral	2008		2009		2010	
	Quantity	Value	Quantity	Value	Quantity	Value
Puerto Rico:						
Cement, portland	1,300	W	936	W	755	W
Clays, common	75	437	54	328	54	328
Lime[e]	11	998	11	1,750	12	3,660
Salt[e]	45	1,500	45	1,500	45	1,500
Stone, crushed	11,000	87,100 [r]	9,450 [r]	72,400 [r]	8,060	68,200
Total	XX	90,000 [r]	XX	76,000 [r]	XX	73,700
Administered Islands:						
American Samoa, stone, crushed	W	W	W	W	W	W
Guam, stone, crushed	325	3,430 [r]	296	3,060 [r]	114	1,180
Virgin Islands, stone, crushed	W	W	W	W	W	W
Total	XX	3,430 [r]	XX	3,060 [r]	XX	1,180

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data. XX Not applicable.

[1] Table includes data available through June 6, 2012.

[2] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[3] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 7
U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value	Quantity	Value
Metals:					
Aluminum:					
Crude and semicrude	metric tons	2,710,000	5,910,000	3,040,000	7,650,000
Manufactures	do.	122,000	479,000	128,000	570,000
Antimony:					
Metal, alloys, waste and scrap	do.	385	2,000	427	2,230
Oxide, antimony content	do.	1,710	9,660	2,120	12,000
Arsenic metal, arsenic content	do.	354	793	481	1,020
Bauxite and alumina:					
Alumina, calcined equivalent		946	488,000	1,520	724,000
Bauxite:					
Calcined, refractory and other grade		21	10,900	19	7,400
Crude and dried		9 r	268 r	21	618
Specialty aluminum compounds, sulfate, chloride, fluoride-based	metric tons	28,500	32,500	37,600	37,600
Beryllium, unwrought, and waste and scrap, other including articles not elsewhere specified, beryllium content	kilograms	22,900	11,700	38,700	24,300
Bismuth, metal, alloys, waste and scrap, bismuth content	do.	397,000	5,820	704,000	8,140
Cadmium:					
Metal	do.	249,000	537	231,000	945
Sulfide, gross weight	do.	16,200	8	46,900	24
Unwrought and powder	do.	276,000	1,270	75,300	571
Waste and scrap	do.	137,000	319	--	--
Chromium:					
Ores and concentrate	metric tons	2,500	1,610	4,420	2,620
Metals and alloys:					
Metal, unwrought powders, waste and scrap, other	do.	411	13,300	597	18,400
Ferroalloys, high-carbon, low-carbon, ferrochromium-silicon	do.	4,780	6,820	9,130	12,900
Chemicals:					
Oxides, trioxide, other	do.	12,000	27,900	19,900	56,700
Sulfates	do.	16	114	60	306
Salts of oxometallic or peroxometallic acids, zinc and lead chromate, sodium dichromate, potassium dichromate, other	do.	20,500	23,100	30,500	31,500
Pigments and preparations	do.	1,220	13,800	2,540	8,640
Cobalt:					
Acetates	do.	648	8,210	406	5,860
Chlorides	do.	10	163	30	650
Oxides and hydroxides	do.	225	5,550	258	2,380
Metal:					
Unwrought, powders, waste and scrap, mattes, other intermediate products of metallurgy	do.	2,120	77,300	2,350	75,000
Copper:					
Unmanufactured, does not include unalloyed scrap, copper content	do.	299,000	1,280,000	276,000	1,630,000
Semimanufactures	do.	194,000	1,140,000	238,000	1,740,000
Scrap, alloyed and unalloyed	do.	843,000	2,010,000	1,030,000	3,550,000
Ferroalloys not listed elsewhere:					
Ferrophosphorous	do.	1,130	2,080	1,030	2,000
Other	do.	3,130	6,840	4,570	9,210
Gold:					
Ores and concentrates	kilograms	2,160	48,600	3,460	102,000
Dore and precipitates	do.	97,400	3,000,000	84,400	3,160,000
Bullion, refined	do.	281,000	8,760,000	295,000	11,400,000
Waste and scrap	do.	728,000	1,750,000	660,000	2,180,000

See footnotes at end of table.

TABLE 7—Continued
U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value	Quantity	Value
Metals—Continued:					
Gold—Continued:					
Metal powder	kilograms	329	8,460	2,340	74,700
Compounds	do.	2,680,000	64,600	4,270,000	107,000
Iron and steel:					
Steel mill products		8,420	NA	11,000	NA
Fabricated steel products		1,560	NA	2,010	NA
Cast iron and steel products		238	NA	287	NA
Iron and steel scrap:					
Ferrous, includes tinplate and terneplate, excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping		22,400	7,120,000	20,500	8,380,000
Pig iron, all grades		11	4,200	2,220	13,400
Direct-reduced iron, steelmaking grade	metric tons	271	38	974	115
Ships, boats, and other vessels for scrapping		4	773	4	743
Used rails for rerolling and other uses, includes mixed (used plus new) rails		59	38,700	49	41,000
Iron ore		3,920	356,000	9,950	1,090,000
Lead:					
Base bullion, lead content	metric tons	34	113	199	757
Ore and concentrates, lead content	do.	287,000	275,000	299,000	472,000
Unwrought and alloys, lead content	do.	77,600	80,100	77,700	84,100
Wrought and alloys, lead content	do.	4,310	8,280	5,590	9,170
Scrap, gross weight	do.	140,000	72,000	43,500	33,800
Magnesium:					
Waste and scrap, magnesium content	do.	2,280	5,200	481	802
Metal, magnesium content	do.	6,120	20,500	5,300	19,800
Alloys, gross weight	do.	9,190	40,400	6,940	30,900
Powder, sheets, tubing, ribbons, wire, other forms, gross weight	do.	2,050	30,500	2,070	36,600
Manganese, gross weight:					
Ores and concentrates with 20% or more manganese	do.	15,300	3,830	13,900	5,990
Ferromanganese, all grades	do.	24,200	27,900	19,100	27,800
Silicomanganese	do.	18,800	17,500	9,360	13,100
Metal, including alloys and waste and scrap	do.	3,150 r	8,090 r	3,660	10,300
Dioxide	do.	8,420	13,400	8,990	14,700
Mercury:					
Metal	do.	753	10,300	459	6,830
Amalgams of precious metals whether or not chemically defined	do.	154	238,000	203	274,000
Molybdenum:					
Ore and concentrates, including roasted and other, molybdenum content	do.	29,600	631,000	40,600	1,050,000
Chemicals:					
Oxides and hydroxides, gross weight	do.	10,600	159,000	6,040	99,300
Molybdates, all, gross weight	do.	1,500	18,000	1,680	26,200
Ferromolybdenum, molybdenum content	do.	827	22,400	978	33,100
Other, includes powders, unwrought, bars and rods, waste and scrap, wire, other, gross weight	do.	1,790	112,000	2,540	153,000
Nickel, nickel content:					
Primary, unwrought and chemicals	do.	7,020	313,000	12,600	345,000
Secondary, stainless steel scrap and waste and scrap	do.	90,000	814,000	80,300	1,030,000
Wrought, not alloyed, bars, rods, profiles, wire, sheets, strip, foil, tubes, pipes	do.	975	24,200	1,900	35,400
Alloyed, unwrought ingot, bars, rods, profiles, wire, sheets, strip, foil, tubes, pipes, other alloyed articles, gross weight	do.	30,700	1,120,000	34,500	1,320,000

See footnotes at end of table.

TABLE 7—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value	Quantity	Value
Metals—Continued:					
Niobium (columbium) and tantalum:					
Niobium:					
Ores and concentrates	kilograms	17,000	954	24,900	228
Ferroniobium	do.	240,000	2,740	395,000	4,190
Tantalum:					
Ores and concentrates, includes synthetic	do.	318,000	2,900	172,000	3,100
Unwrought powders, waste and scrap, unwrought alloys and metal	do.	179,000	50,100	315,000	79,000
Wrought	do.	52,200	26,900	65,200	35,900
Platinum-group metals:					
Palladium, palladium content	do.	30,300	229,000	38,100	419,000
Platinum, includes waste and scrap and metal, platinum content	do.	47,100	1,040,000	55,100	1,880,000
Iridium, osmium, ruthenium, gross weight	do.	4,020	34,400	3,720	36,800
Rhodium, rhodium content	do.	1,220	48,400	2,320	136,000
Rare earths, estimated rare-earth oxide content:					
Cerium compounds	do.	840,000	8,040	1,350,000	14,300
Ferrocerium and other pyrophoric alloys	do.	2,970,000	28,000	3,460,000	19,000
Compounds, inorganic and organic	do.	455,000	6,210	1,690,000	27,200
Metals, including scandium and yttrium	do.	4,920,000	15,700	1,380,000	27,500
Selenium and tellurium:					
Selenium, selenium content	do.	618,000 [r]	10,400 [r]	919,000	16,000
Tellurium, tellurium content	do.	8,130	1,210	59,000	5,400
Silicon, gross weight:					
Ferrosilicon	metric tons	14,200	16,900	25,400	29,600
Metal	do.	37,900	2,070,000	65,900	2,700,000
Silver:					
Bullion, silver content	kilograms	167,000	93,600	523,000	326,000
Dore, silver content	do.	130,000	72,700	104,000	45,900
Metal powder, gross weight	do.	834,000	434,000	1,280,000	874,000
Nitrate, gross weight	do.	27,900	2,690	53,500	4,540
Ores and concentrates, silver content	do.	122,000	55,400	82,100	47,700
Semimanufactured forms containing 99.5% or more by weight of silver, gross weight	do.	525,000	252,000	617,000	353,000
Waste and scrap, gross weight	do.	2,480,000	4,300,000	3,760,000	5,990,000
Unwrought, other, gross weight	do.	59,000	21,200	87,300	49,800
Thorium:					
Ore, monazite concentrate	do.	18,000	269 [e]	(3)	15
Thorium and thorium-bearing materials, compounds	do.	4,730	379	1,500	605
Tin:					
Ingots and pigs	metric tons	3,170	22,200	5,630	35,900
Tin scrap and other tin bearing material, except tinplate scrap, includes rods, profiles, wire, powders, flakes, tubes, pipes	do.	11,600	46,200	15,600	70,300
Tinplate and terneplate	do.	224,000	175,000	209,000	171,000
Titanium:					
Metal, waste and scrap, unwrought, wrought products and castings, ferrotitanium and ferrosilicon titanium	do.	23,300	799,000	24,100	868,000
Ores and concentrates	do.	14,800	8,230	18,900	11,800
Pigment, dioxide and oxide	do.	649,000	1,310,000	758,000	1,690,000
Tungsten, tungsten content:					
Ammonium paratungstate	do.	375	5,990	538	8,840
Carbide powder	do.	468 [r, e]	19,600	1,220 [e]	43,600
Metal powders	do.	360 [r, e]	25,500	803 [e]	39,600

See footnotes at end of table.

TABLE 7—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value	Quantity	Value
Metals—Continued:					
Tungsten, tungsten content—Continued:					
Miscellaneous tungsten-bearing materials, ferrotungsten, ferrosilicon tungsten, unwrought, waste and scrap, wrought, compounds	metric tons	1,520	48,600	1,790	60,200
Ores and concentrates	do.	38 [e]	1,080	276 [e]	6,450
Vanadium:					
Aluminum-vanadium master alloy, gross weight	kilograms	11,200,000	27,800	11,900,000	33,300
Ferrovanadium, vanadium content	do.	672,000	15,000	611,000	18,100
Metal, including waste and scrap, gross weight	do.	22,700	1,040	21,200	671
Pentoxide, anhydride, vanadium content	do.	401,000	4,970	140,000	2,140
Other oxides and hydroxides, vanadium content	do.	506,000	5,270	1,100,000	10,600
Zinc:					
Compounds, chloride, chromates of zinc or of lead, compounds n.s.p.f.[4], lithopone, oxide, sulfate, sulfide, gross weight	metric tons	25,400	47,500	26,800	53,700
Ores and concentrates, zinc content	do.	785,000	656,000	752,000	903,000
Rolled	do.	6,160	17,700	7,380	NA
Slab	do.	2,960	3,070	4,200	NA
Zirconium:					
Ferrozirconium	do.	566	1,140	569	1,200
Ores and concentrates	do.	39,600	36,300	47,400	51,100
Oxide, includes germanium oxides and zirconium dioxides	do.	3,050	31,400	5,630	59,000
Unwrought powders	do.	165	7,660	438	16,400
Waste and scrap	do.	2,140	192,000	1,620	147,000
Total		XX	49,100,000	XX	65,300,000
Industrial minerals:					
Abrasives, manufactured:					
Aluminum oxide, crude	metric tons	12,300	32,000	20,000	67,900
Metallic abrasives	do.	25,900	32,200	30,800	41,300
Silicon carbide, crude, ground and refined	do.	20,700	37,700	23,100	56,000
Asbestos, includes reexports:					
Manufactured		NA	24,500	NA	27,000
Unmanufactured	metric tons	59	69	171	121
Barite, natural barium sulfate	do.	49,300	10,200	109,000	17,800
Boron minerals and compounds:					
Boric acid, includes orthoboric and anhydrous		171	109,000	264	170,000
Sodium borates		417	176,000	423	218,000
Bromine:					
Compounds, includes methyl bromine and ethylene dibromide, bromine content	metric tons	2,310	6,510	3,620	14,300
Elemental, gross weight	do.	3,810	5,930	4,530	7,970
Cement, hydraulic and clinker[5]		884	107,000	1,180	168,000
Clays:					
Ball		35	2,430	45	3,300
Bentonite		709	100,000	953	143,000
Fire		328	42,800	404	61,500
Fuller's earth		90	28,500	100	35,400
Kaolin		2,290	459,000	2,470	537,000
Other, n.e.c.[6], includes chamotte or dinas earth, activated clays and earths, artificially activated clays		374	69,500	383	82,600
Diamond:					
Gemstones, natural, including reexports	thousand carats	25,200	9,940,000	23,700	14,100,000

See footnotes at end of table.

TABLE 7—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value	Quantity	Value
Industrial minerals—Continued:					
Diamond—Continued:					
Industrial including exports and reexports:					
Unworked	thousand carats	948 r	17,500	1,080	23,400
Powder, dust and grit, natural and synthetic	do.	76,900	37,600	131,000	61,500
Diatomite		88	41,100	86	44,500
Feldspar	metric tons	7,520	1,150	16,800	2,280
Fluorspar	do.	14,100	2,230	17,900	2,740
Garnet, industrial	do.	13,200	10,700	11,700	14,400
Graphite, natural and artificial	do.	46,400	130,000	45,600	152,000
Gypsum and gypsum products:					
Crude		156	16,000	360	19,300
Plasters		155	37,800	190	42,200
Boards		665	120,000	729	129,000
Other		XX	50,200	XX	66,200
Helium, Grade-A	million cubic meters	71	160,000	77	179,000
Iodine:					
Crude, resublimed	metric tons	1,160	22,900	1,070	22,300
Potassium iodide	do.	128 r	2,720	442	9,330
Iron oxide pigments and hydroxides:					
Pigment grade	do.	5,640	15,500	9,490	17,000
Other grade	do.	11,300	18,500	44,700	34,400
Kyanite, andalusite, sillimanite[e]		26	7,510	38	11,300
Lime		108	18,500	215	36,200
Lithium chemicals:					
Carbonate	metric tons	1,030	7,040 r	1,370	7,910
Hydroxide	do.	4,400	31,600	6,960	43,600
Magnesium compounds:					
Compounds, chlorides, hydroxide and peroxide, sulfates	do.	37,800	28,300	34,900	25,100
Magnesite, crude and processed:					
Caustic-calcined magnesia	do.	503	296	278	165
Dead-burned and fused magnesia	do.	8,390	5,950	8,650	6,550
Other magnesia	do.	12,700	13,500	18,100	20,300
Crude	do.	10,500	1,480	8,920	1,310
Mica:					
Scrap and flake:					
Powder	do.	5,940	8,850	5,550	8,190
Waste	do.	2,090	1,600	935	468
Sheet:					
Unworked	do.	96	437	53	163
Worked	do.	1,020	15,300	879	15,900
Nitrogen, major compounds, gross weight		9,280	NA	7,910	NA
Peat		77	8,570	69	7,230
Perlite, crude[e]	metric tons	33,000	NA	42,000	NA
Phosphate rock:					
Diammonium phosphate		5,530	1,820,000	4,090	1,710,000
Elemental phosphorus		17	66,000	18	56,600
Monoammonium phosphate		2,110	717,000	2,330	1,000,000
Phosphoric acid		535	142,000	673	235,000
Potash:					
Potassium chloride	metric tons	342,000	NA	248,000	NA

See footnotes at end of table.

TABLE 7—Continued

U.S. EXPORTS OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value	Quantity	Value
Industrial minerals—Continued:					
Potash—Continued:					
Potassium sulfates, all grades	do.	355,000	NA	555,000	NA
Potassium nitrate	do.	8,450	6,250	9,990	9,070
Pumice and pumicite		11	5,130 [r]	13	5,970
Salt		1,450	74,100	595	69,300
Sand and gravel:					
Construction:					
Sand		79	19,000	59	16,600
Gravel		360	4,050	322	6,010
Industrial		2,150	175,000	3,950	323,000
Silica, special stone products		NA	7,640	NA	11,300
Soda ash		4,410	838,000	5,390	886,000
Stone:					
Crushed		1,260	58,300	1,210	52,100
Dimension		XX	48,300	XX	54,500
Strontium compounds:					
Carbonate, precipitated	kilograms	159,000 [r]	107	121,000	105
Oxide, hydroxide, peroxide	do.	614,000 [r]	355 [r]	707,000	395
Sulfur:					
Elemental		1,430	82,200	1,450	171,000
Sulfuric acid, 100% H_2SO_4		254	23,900	215	26,400
Talc, excludes powders-talcum (in package), face, compact		188	37,600	224	47,200
Vermiculite[e]		3	610	2	575
Wollastonite[e]	metric tons	10,000 [r]	3,060 [r]	10,000	3,120
Zeolites[e]	do.	200	47	400	94
Total		XX	16,200,000 [r]	XX	21,500,000
Grand total		XX	65,300,000 [r]	XX	86,800,000

[e] Estimated. [r] Revised. do. Ditto. NA Not available. XX Not applicable. -- Zero.

[1] Table includes data available through June 6, 2012.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Less than ½ unit.

[4] Not specifically provided for.

[5] Excludes Puerto Rico.

[6] Not elsewhere classified.

TABLE 8

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value[3]	Quantity	Value[3]
Metals:					
Aluminum:					
Crude and semicrude	metric tons	4,110,000	7,980,000	4,120,000	10,300,000
Manufactures	do.	264,000	732,000	281,000	930,000
Antimony:					
Metal	do.	4,750	19,600	5,360	39,100
Ore and concentrate, antimony content	do.	167	1,010	181	1,840
Oxide, antimony content	do.	15,200	81,000	20,600	144,000
Arsenic:					
Acid	do.	3	11	60	43
Metal	do.	438	1,890	769	2,440
Sulfide	do.	77	334	13	35
Trioxide	do.	6,130	2,740	5,920	2,830
Bauxite and alumina:					
Alumina, calcined equivalent		1,860	613,000	1,720	711,000
Bauxite:					
Calcined, refractory and other grade		461	91,600 r	691	146,000
Crude and dried		6,970	355,000 r, 4	8,120	411,000 4
Specialty aluminum compounds, sulfate, chloride, fluoride-based	metric tons	30,700	30,600	50,200	53,300
Beryllium, ore, concentrates, oxide, hydroxide, unwrought including powders, waste and scrap, other, beryllium-copper master alloys, beryllium-copper plates, sheets, strip, beryllium content	kilograms	23,800	5,720	271,000	20,600
Bismuth, metallic	do.	1,250,000	20,600	1,620,000	30,100
Cadmium:					
Metal	do.	4,940	371	4,910	509
Sulfide, gross weight	do.	135,000	2,430	255,000	3,400
Unwrought and powder	do.	117,000	1,110	216,000	2,400
Waste and scrap		--	--	59	6
Chromium:					
Chromite ore	metric tons	77,200	17,500	139,000	29,600
Metals and alloys:					
Ferroalloys, high-carbon, low-carbon, ferrochromium-silicon	do.	248,000	294,000	524,000	791,000
Metal, unwrought powders, waste and scrap, other	do.	7,570	74,900	13,000	148,000
Chemicals:					
Oxides, hydroxides, trioxide and other	do.	9,100	28,000	8,240	27,900
Sulfates	do.	71	88	325	351
Salts of oxometallic or peroxometallic acids, zinc and lead chromate, sodium dichromate, potassium dichromate, other	do.	15,300	18,100	769	2,730
Carbide	do.	165	3,060	242	4,370
Pigments and preparations based on chromium	do.	1,700	8,650	2,280	11,600
Cobalt:					
Metal:					
Unwrought, excluding alloys and waste and scrap, includes cathode and metal powder, may include intermediate products of cobalt metallurgy	do.	5,870	198,000	8,750	350,000
Oxide and hydroxides, content	do.	1,050 r	37,500	1,450	60,700
Other forms, includes acetates, carbonates, chlorides, sulfates, content	do.	751 r	27,300	854	28,900
Copper:					
Unmanufactured, does not include unalloyed scrap, copper content	do.	733,000	3,510,000	634,000	4,680,000
Semimanufactures	do.	225,000	1,050,000	234,000	1,630,000
Scrap, alloyed and unalloyed	do.	71,800	237,000	95,800	403,000
Ferroalloys not listed elsewhere:					
Ferrophosphorus	metric tons	138	617	7,650	4,180

See footnotes at end of table.

TABLE 8—Continued
U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value[3]	Quantity	Value[3]
Metals—Continued:					
Ferroalloys not listed elsewhere—Continued:					
Other	do.	4,710	13,900	8,730	27,900
Gallium:					
Unwrought and waste and scrap	kilograms	35,900	12,600	59,200	19,200
Gallium arsenide wafers, doped and undoped	do.	145,000	131,000	229,000	191,000
Germanium, wrought, unwrought, waste and scrap, gross weight	do.	29,400	39,100	27,000	25,900
Gold:					
Ores and concentrates	kilograms	46,600	33,100	257,000	58,000
Dore and precipitates	do.	146,000	4,260,000	148,000	4,520,000
Bullion, refined	do.	127,000	3,580,000	199,000	7,020,000
Waste and scrap	do.	43,400	600,000 [r]	46,100	722,000
Metal powder	do.	476	8,760	652	11,500
Compounds	do.	64,300	1,430	43,500	1,480
Indium, unwrought metal	do.	105,000	35,200	117,000	58,700
Iron and steel:					
Steel mill products		14,700	NA	21,700	NA
Fabricated steel products		3,530	NA	4,110	NA
Cast iron and steel products		464	NA	605	NA
Stainless steel	metric tons	515,000 [r]	NA	813,000	NA
Iron and steel scrap:					
Ferrous, includes tinplate and terneplate, excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping		2,990	831,000 [r]	3,780	1,420,000
Pig iron, all grades		2,420	877,000	3,780	1,540,000
Direct-reduced iron, steelmaking grade		1,020	304,000	1,640	607,000
Ships, boats, and other vessels for scrapping		(5)	79	(5)	226
Used rails for rerolling and other uses, includes mixed (used plus new) rails		57	17,700	53	23,700
Iron ore		3,870	376,000	6,420	703,000
Lead:					
Pigs and bars, lead content	metric tons	251,000	408,000 [r]	271,000	559,000
Pigments and compounds, lead content	do.	28,100	46,800	28,600	61,000
Scrap, reclaimed, includes ash and residues, lead content	do.	1,330	2,620	3,730	8,880
Wrought, all forms, including wire and powders, gross weight	do.	1,340	5,490 [r]	1,290	6,270
Magnesium:					
Waste and scrap, gross weight	do.	20,900	40,300	22,100	56,500
Metal, gross weight	do.	21,400	86,800	18,200	83,500
Alloys, magnesium content	do.	4,790	29,800	11,600	54,400
Powder, sheets, tubing, ribbons, wire, other forms, magnesium content	do.	205	4,170	788	9,160
Manganese:					
Ores and concentrates with 20% or more manganese, manganese content	do.	154,000	82,600	255,000	133,000
Ferromanganese, all grades, manganese content	do.	121,000	215,000	257,000	493,000
Silicomanganese, manganese content	do.	83,500	135,000	197,000	373,000
Metal, unwrought, other wrought, waste and scrap, gross weight	do.	23,000	57,800	36,000	95,400
Chemicals, manganese dioxide and potassium permanganate, gross weight	do.	18,600	45,800	23,000	58,400
Mercury:					
Metal	do.	206	1,350	294	1,290
Amalgams of precious metals whether or not chemically defined	do.	14	31,300	23	70,000
Molybdenum:					
Ores and concentrates, including roasted and other, molybdenum content	metric tons	7,520	150,000	12,900	314,000
Chemicals, gross weight:					
Oxides and hydroxides	do.	209	3,330	508	12,200
Molybdates, all, molybdenum content	do.	657	20,500	928	30,100

See footnotes at end of table.

TABLE 8—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009 Quantity	2009 Value[3]	2010 Quantity	2010 Value[3]
Metals—Continued:					
Molybdenum—Continued:					
Chemicals, gross weight—Continued:					
Orange	do.	269	2,170	350	2,730
Ferromolybdenum, molybdenum content	do.	2,030	50,100	3,560	130,000
Other, includes powders, unwrought, bars and rods, waste and scrap, wire, other, gross weight	do.	970	43,000	1,840	87,800
Nickel, nickel content:					
Primary, unwrought and chemicals	do.	99,900	1,480,000	129,000	2,790,000
Secondary, stainless steel scrap and waste and scrap	do.	17,700	249,000	23,800	472,000
Wrought, not alloyed, bars, rods, profiles, wire, sheets, strip, foil, tubes, pipes	do.	409	14,000	677	21,100
Alloyed, unwrought ingot, bars, rods, profiles, wire, sheets, strip, foil, tubes, pipes, other alloyed articles	do.	17,300	439,000	21,500	565,000
Niobium (columbium) and tantalum:					
Niobium:					
Ores and concentrates	kilograms	4,960	360	11,600	494
Oxide	do.	1,060,000	29,000	1,180,000	35,800
Ferroniobium	do.	4,490,000	109,000	9,660,000	237,000
Unwrought powders	do.	699,000	24,100	1,380,000	56,900
Tantalum:					
Ores and concentrates, includes synthetic concentrates	do.	357,000	13,600	19,800	2,520
Unwrought powders, waste and scrap, unwrought alloys and metal	do.	613,000	92,800	1,470,000	140,000
Wrought	do.	75,600	20,800	114,000	31,500
Platinum-group metals, metal content:					
Platinum, grains and nuggets, sponge, other unwrought, other, waste and scrap, coins	do.	183,000	2,080,000	152,000	2,510,000
Palladium, unwrought and other	do.	69,700	631,000	70,700	1,110,000
Iridium, unwrought and other forms	do.	1,520	20,800	3,530	65,900
Osmium, unwrought	do.	68	551	76	612
Ruthenium, unwrought	do.	21,200	55,700	14,100	82,500
Rhodium, unwrought and other forms	do.	11,200	530,000	12,800	914,000
Rare earths, estimated equivalent rare-earth oxide (REO) content:					
Cerium compounds, including oxides, hydroxides, nitrates, sulfate chlorides, oxalates	do.	1,500,000	9,070	1,770,000	22,600
Ferrocerium and other pyrophoric alloys	do.	102,000	2,620	131,000	3,110
Mixtures of rare-earth chlorides, except cerium chloride	do.	411,000	4,930	956,000	12,000
Mixtures of REOs except cerium oxide	do.	4,750,000	23,500	5,480,000	38,300
Compounds, including oxides, hydroxides, nitrates, other compounds except chlorides	do.	5,080,000 r	67,500	3,980,000	96,300
Metals, whether intermixed or alloyed	do.	226,000	4,870	525,000	14,700
Yttrium compounds content by weight greater than 19% but less than 85% oxide equivalent	do.	6,920	565 r	73,500	2,060
Rhenium:					
Metal	do.	21,500	53,100	23,100	52,800
Ammonium perrhenate	do.	14,300	13,700	25,500	17,900
Selenium and tellurium:					
Selenium, selenium content:					
Selenium	do.	260,000	12,700	491,000	34,100
Dioxide	do.	3,420	210	9,170	626
Tellurium, tellurium content	do.	84,000	11,300	41,600	9,040
Silicon, gross weight:					
Ferrosilicon	metric tons	103,000	126,000	229,000	342,000
Metal	do.	116,000	477,000	175,000	748,000

See footnotes at end of table.

TABLE 8—Continued
U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1,2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value[3]	Quantity	Value[3]
Metals—Continued:					
Silver:					
Ash and residues, silver content	kilograms	505	151	316	77
Bullion, silver content	do.	2,800,000	1,310,000	4,330,000	2,890,000
Dore, silver content	do.	653,000	439,000	738,000	708,000
Metal powder, gross weight	do.	247,000	36,400	788,000	170,000
Nitrate, gross weight	do.	835	241	1,430	390
Ores and concentrates, silver content	do.	87	9	3,230	1,750
Semimanufactured forms containing 99.5% or more by weight of silver, gross weight	do.	476,000	176,000	638,000	354,000
Waste and scrap, gross weight	do.	4,760,000	372,000	6,510,000	435,000
Unwrought, other, gross weight	do.	135,000	56,100	316,000	142,000
Thallium, unwrought powders, waste and scrap, other	do.	2,030	312	783	204
Thorium:					
Ore, monazite concentrate	do.	26,000	20	--	--
Thorium and thorium-bearing materials, compounds	do.	2,250	275	3,030	208
Tin, gross weight:					
Compounds	metric tons	601	8,180	753	13,300
Dross, skimmings, scrap, residues, alloys, n.s.p.f.[6]	do.	81,300	23,400	58,000	30,700
Metal, unwrought	do.	33,000	404,000	35,300	658,000
Miscellaneous, includes tinfoil, tin powder, flitters, metallics, manufactures, n.s.p.f.[6]	do.	XX	36,200	XX	53,200
Tinplate and terneplate, gross weight	do.	295,000	366,000	464,000	500,000
Tinplate scrap, gross weight	do.	27,100	5,190	68,000	14,300
Titanium:					
Concentrate:					
Ilmenite	do.	250,000	21,800	377,000	37,600
Rutile, natural and synthetic	do.	279,000	141,000	351,000	198,000
Metal:					
Waste and scrap	do.	4,770	17,600	10,700	75,500
Unwrought	do.	16,600	178,000	20,500	196,000
Ingots	do.	531	13,300	237	3,880
Powder	do.	24	2,390	119	5,420
Other	do.	18	1,220	88	3,980
Wrought products and castings, includes bar, castings, foil, pipe, plate, profile, rod, sheet, strip, tube, wire, other	do.	6,930	292,000	8,710	299,000
Ferrotitanium and ferrosilicon titanium	do.	2,540	6,750	2,740	11,500
Pigment, dioxide and oxide	do.	175,000	385,000	204,000	462,000
Titaniferous iron ore	do.	10,000	532	83,100	6,760
Titaniferous slag	do.	414,000	168,000	475,000	200,000
Tungsten, tungsten content:					
Ammonium paratungstate	do.	2,540	52,600	2,510	56,400
Ferrotungsten and ferrosilicon tungsten	do.	46	1,260	357	11,000
Miscellaneous tungsten-bearing materials, metal powders, carbide powder, unwrought, waste and scrap, wrought, oxides, calcium tungstate, other tungstates, other compounds	do.	3,820 [r]	135,000	6,820	237,000
Ores and concentrates	do.	3,590	72,900	2,740	60,000
Vanadium:					
Aluminum-vanadium master alloy, gross weight	kilograms	282,000	979	9,200,000	27,800
Ferrovanadium, vanadium content	do.	353,000	12,600	1,340,000	41,100
Metal, including waste and scrap, gross weight	do.	21,700	940	9,660	434
Miscellaneous chemicals, sulfates and vanadates, vanadium content	do.	231,000	3,570	205,000	4,620
Pentoxide, anhydride, vanadium content	do.	1,120,000	16,500	4,000,000	55,700

See footnotes at end of table.

TABLE 8—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value[3]	Quantity	Value[3]
Metals—Continued:					
Vanadium—Continued:					
Vanadium-bearing ash and residues from the manufacture of iron and steel, vanadium oxide content	do.	791,000	12,300	521,000	5,570
Other oxides and hydroxides, vanadium content	do.	25,200	551	167,000	3,330
Zinc:					
Compounds, chloride, chromates of zinc or of lead, compounds n.s.p.f.[6], lithopone, oxide, sulfate, sulfide, gross weight	metric tons	104,000	127,000	136,000	226,000
Ores and concentrates, zinc content	do.	74,200	68,300	32,200	NA
Rolled	do.	3,010	13,500	3,440	NA
Slab, refined	do.	686,000	1,080,000	671,000	NA
Zirconium and hafnium:					
Hafnium, unwrought, including powders	do.	5	2,080	8	3,390
Zirconium:					
Ferrozirconium	do.	(5)	7	45	246
Ores and concentrates	do.	14,400	17,100	22,900	27,500
Oxide, includes germanium oxides and zirconium oxides	do.	2,810	43,800	2,920	52,700
Unwrought powder	do.	22	1,890	31	2,330
Waste and scrap	do.	955	58,400	1,130	70,700
Total		XX	41,400,000 r	XX	61,400,000
Industrial minerals:					
Abrasives, manufactured:					
Aluminum oxide, crude, ground and refined	do.	64,200	53,700	185,000	136,000
Metallic abrasives	do.	15,800	12,100	43,400	25,300
Silicon carbide, crude, ground and refined	do.	78,000	74,500	143,000	165,000
Asbestos:					
Chrysotile and other unspecified type	metric tons	869	684	1,040	821
Products with basis of asbestos, cellulose, or other minerals		NA	13,300	NA	5,790
Barite:					
Chloride, oxide, hydroxide, peroxide, precipitated carbonate	metric tons	4,170	6,250	7,430	7,900
Crude	do.	572,000	60,000 r	873,000	87,300
Ground	do.	851,000	58,100	1,220,000	91,500
Other sulfates	do.	10,600	10,900	14,700	17,000
Boron minerals and compounds:					
Borax		(5)	376	(5)	183
Boric acid		36	26,100	50	30,100
Colemanite		31	8,630	50	18,400
Ulexite		28	11,300	1	238
Bromine:					
Compounds, contained bromine	metric tons	33,600 r	80,300	43,900	85,400
Elemental	do.	1,390	3,020	1,040	2,620
Cement, hydraulic and clinker[7]		6,770	502,000	6,630	490,000
Clays:					
China clay or kaolin		281	68,700	239	56,300
Fire clay		(5)	133	(5)	179
Decolorizing earths and fuller's earth		1	96	2	160
Bentonite		8	2,460	16	4,670
Common blue clay and other ball clay		--	--	1	138
Other clay		8	3,940	7	4,560
Chamotte or dina's earth		(5)	165	(5)	110
Artificially activated clay and activated earth		27	28,800	19	25,800

See footnotes at end of table.

TABLE 8—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value[3]	Quantity	Value[3]
Industrial minerals—Continued:					
Diamond, industrial:					
Diamond stones, natural and miners'	thousand carats	1,400	18,700	1,720	32,300
Powder, dust and grit, natural and synthetic	do.	246,000	41,000 r	596,000	86,500
Diatomite, siliceous fossil meals	metric tons	1,260	1,080	1,030	894
Feldspar and nepheline syenite:					
Feldspar	do.	2,120	646	2,050	503
Nepheline syenite	do.	308,000	36,800	368,000	52,400
Fluorspar:					
Aluminum fluoride	do.	18,700	26,800	38,000	49,200
Cryolite	do.	2,830	3,630	5,320	6,510
Fluorspar	do.	475,000	105,000	539,000	103,000
Hydrofluoric acid	do.	114,000	161,000	135,000	199,000
Garnet, industrial	do.	37,900	8,890	42,500	11,100
Gemstones	thousand carats	1,200,000	13,500,000 r	1,520,000	19,600,000
Graphite:					
Natural	metric tons	33,100	29,700	65,400	52,100
Electric furnace electrodes	do.	50,600	190,000	88,200	342,000
Gypsum:					
Crude		4,220	52,900	3,330	41,800
Plasters		15	6,800	15	7,180
Boards		236	38,500	244	32,400
Other		XX	30,300	XX	29,600
Iodine:					
Crude	metric tons	5,190	133,000	5,710	141,000
Potassium iodide	do.	259	6,000	423	9,770
Iron oxide pigments:					
Natural	do.	1,900	1,070	3,360	2,390
Synthetic	do.	105,000	126,000	148,000	164,000
Kyanite, andalusite, sillimanite	do.	4,880	2,060	2,180	938
Lime		422	53,200	445	61,500
Lithium chemicals:					
Carbonate	metric tons	9,250	41,900	9,500	41,300
Hydroxide	do.	932	5,580	1,070	5,300
Magnesium compounds:					
Compounds, chlorides, hydroxide, peroxide, sulfates	do.	133,000	38,500	122,000	49,000
Magnesite, crude and processed:					
Caustic-calcined magnesia	do.	126,000	37,700	127,000	40,300
Dead-burned and fused magnesia	do.	151,000	72,200	323,000	161,000
Other magnesia	do.	8,740	8,750	12,000	14,500
Crude	do.	6,270	3,830	22,400	8,420
Mica:					
Scrap and flake:					
Powder	metric tons	16,900	9,540	22,000	16,900
Waste	do.	2,990	1,670	4,400	2,390
Sheet:					
Unworked	do.	23	142	51	180
Worked	do.	1,480 r	14,400	1,930	16,200
Nitrogen, major compounds, gross weight		12,600	3,570,000	9,640	5,930,000
Peat moss	metric tons	906,000	230,000	947,000	225,000
Perlite, processed crude	do.	153,000	15,900	174,000	17,700

See footnotes at end of table.

TABLE 8—Continued

U.S. IMPORTS FOR CONSUMPTION OF PRINCIPAL MINERALS AND PRODUCTS, EXCLUDING MINERAL FUELS [1,2]

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral or product		2009		2010	
		Quantity	Value[3]	Quantity	Value[3]
Industrial minerals—Continued:					
Phosphate rock and phosphatic materials:					
Phosphate rock:					
Unground					
Ground		988	83,100 [4]	1,280	117,000 [4]
Dicalcium phosphate		379	26,900 [4]	605	48,900 [4]
Elemental phosphorus		6	11,200 [4]	7	9,990 [4]
Normal superphosphate		4	15,600 [4]	7	23,500 [4]
Triple superphosphate		(5)	114 [4]	4	1,400 [4]
Diammonium phosphate		38	9,340 [4]	189	66,900 [4]
Monoammonium phosphate		22	9,710 [4]	190	101,000 [4]
Fertilizer containing nitrates and phosphates		62	38,800 [4]	269	151,000 [4]
Phosphoric acid		1	492 [4]	(5)	182 [4]
Potash, chloride, sulfate, nitrate, sodium nitrate mixtures		31	30,600 [4]	31	20,600 [4]
Pumice:		3,670	1,720,000 [r]	7,840	2,620,000
Crude or unmanufactured					
Wholly or partially manufactured	do.	26,000	784	34,100	758
Salt	do.	258	832	1,140	1,430
Sand and gravel:		14,700	337,000	12,900	322,000
Construction					
Industrial		2,980	66,100 [4]	2,670	95,900 [4]
Silica, special stone products[8]		95	8,080	131	19,700
Soda ash		NA	8,320	NA	8,990
Stone:		6	2,350	20	5,770
Crushed, chips, calcium carbonate fines, excludes precipitated carbonates					
Dimension		12,200	174,000 [4]	14,500	185,000 [4]
Strontium:		XX	1,350,000	XX	2,430,000
Carbonate					
Celestite	kilograms	7,820,000	5,090	11,700,000	8,310
Metal	do.	14,600,000	690	5,400,000	245
Nitrate	do.	70,100	564	118,000	686
Oxide, hydroxide, peroxide	do.	2,770,000	2,770	3,580,000	4,760
Sulfur:	do.	6,720	51	129,000	185
Elemental					
Sulfuric acid, 100% H_2SO_4		1,700 [e]	54,100	2,950 [e]	214,000
Talc, unmanufactured		1,270 [r]	146,000	2,110	139,000
Vermiculite[e]		134 [r]	47,900	242	67,100
Wollastonite[e]		39	7,100	29	9,740
Zeolites[e]	metric tons	4,000	530	4,000	540
Total	do.	300	64	150	32
Grand total		XX	23,900,000 [r]	XX	35,600,000
		XX	65,200,000 [r]	XX	96,900,000

[e]Estimated. [r]Revised. do. Ditto. NA Not available. XX Not applicable. -- Zero.

[1] Table includes data available through June 6, 2012.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Customs value unless otherwise specified.

[4] Cost, insurance, and freight value.

[5] Less than ½ unit.

[6] Not specifically provided for.

[7] Excludes Puerto Rico.

[8] Hand sharpening or polishing stones.

TABLE 9

WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES [1]

(Thousand metric tons unless otherwise specified)

Mineral or product		World total 2006	World total 2007	World total 2008	World total 2009	World total 2010	United States 2010	United States Percentage of world total
Metals:								
Alumina		72,400 r	77,900 r	82,500 r	76,700 r	85,300	3,910	4.6
Aluminum[2]		33,900 r	38,000 r	39,600 r	36,900 r	40,800	1,730	4.2
Antimony	metric tons	173,000 r	180,000 r	182,000 r	154,000 r	167,000	--	--
Arsenic trioxide[3]	do.	60,900 r	55,400 r	53,400 r	54,100 r	52,800	--	--
Bauxite[3, 4, 5]		193,000 r	204,000 r	211,000 r	196,000 r	212,000	NA	NA
Beryl[3]	metric tons	4,360	4,360	4,940	3,590	5,080	4,460	87.9
Bismuth, refinery	do.	15,300	15,500	16,600 r	15,400 r	16,000	--	--
Cadmium, refinery	do.	19,900	19,400	22,800 r	20,800 r	21,100	637	3.0
Chromite[3]		19,700 r	22,800 r	24,000 r	19,500 r	23,700	--	--
Cobalt, Co content:								
Mine	metric tons	70,000 r	71,700 r	76,400 r	72,100 r	89,500	--	--
Refinery	do.	53,800	53,300	57,300 r	59,700 r	76,400	--	--
Copper:								
Mine		15,100 r	15,500 r	15,600 r	15,900 r	16,000	1,110	6.9
Smelter		14,100 r	14,300 r	14,700 r	14,900 r	15,600	601	3.8
Refinery		17,300 r	17,900 r	18,300 r	18,400 r	19,100	1,090	5.7
Gold	metric tons	2,370 r	2,350 r	2,280 r	2,460 r	2,560	231	9.0
Indium, refinery	kilograms	638,000 r	631,000 r	613,000 r	583,000 r	659,000	--	--
Iron ore[3]		1,830,000 r	2,040,000 r	2,210,000 r	2,230,000 r	2,590,000	49,900	1.9
Iron and steel:								
Direct-reduced iron[2]		58,700 r	64,100 r	66,700 r	65,700 r	68,700	--	--
Pig iron[2]		881,000 r	956,000 r	931,000 r	920,000 r	1,026,000	26,800	2.6
Raw steel		1,250,000 r	1,350,000 r	1,330,000 r	1,240,000 r	1,420,000	80,500	5.7
Lead:								
Mine, Pb content		3,630 r	3,720 r	3,880 r	3,900 r	4,140	369	8.9
Refinery		8,100 r	8,300 r	8,770 r	8,890 r	9,490	1,250	13.2
Magnesium[5]	metric tons	675,000	751,000	670,000	598,000 r	757,000	W	NA
Manganese ore[3]		33,100 r	35,100 r	38,300 r	33,800 r	42,700	--	--
Mercury[5]	metric tons	1,150	1,200	1,820 r	1,960 r	2,250	NA [6]	NA
Molybdenum, Mo content	do.	186,000 r	212,000 r	218,000 r	221,000 r	242,000	59,400 [7]	24.6
Nickel, Ni content:								
Mine		1,570 r	1,650 r	1,580 r	1,410 r	1,620	--	--
Refinery		1,350 r	1,440 r	1,390 r	1,400 r	1,470	--	--
Niobium (columbium)-tantalum concentrates[3]	metric tons	223,000	263,000	264,000 r	263,000 r	261,000	--	--
Platinum-group metals	kilograms	515,000 r	511,000 r	468,000 r	449,000 r	467,000	15,100	3.2
Rhenium	do.	46,700 r	47,500 r	54,900 r	45,400 r	47,200	W	NA
Selenium[2, 5]	metric tons	2,090 r	2,200 r	2,180 r	2,190 r	2,120	W	NA
Silver	do.	20,000 r	20,800 r	21,400 r	22,000 r	23,100	1,280	5.5
Tellurium[2, 5]	kilograms	116,000	124,000	128,000 r	129,000 r	123,000	W	NA
Tin:								
Mine	metric tons	293,000 r	303,000 r	257,000 r	264,000 r	265,000	--	--
Smelter[8]	do.	339,000 r	346,000 r	333,000 r	340,000 r	350,000	10,900	3.1
Tungsten, W content	do.	56,600 r	53,500 r	62,300 r	61,000 r	68,800	W	NA
Vanadium	do.	57,900	58,500	56,400	51,400 r	57,600	--	--
Zinc:								
Mine, Zn content of concentrate and direct shipping ore		10,300 r	11,000 r	11,700 r	11,400 r	12,000	748	6.2
Smelter		10,800 r	11,400 r	11,700 r	11,300 r	12,700	249	2.0

See footnotes at end of table.

TABLE 9—Continued

WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES [1]

(Thousand metric tons unless otherwise specified)

Mineral or product		World total 2006	World total 2007	World total 2008	World total 2009	World total 2010	United States 2010	United States Percentage of world total
Industrial minerals:								
Asbestos		2,150 [r]	2,250 [r]	2,110 [r]	2,130 [r]	2,010	--	--
Barite		7,910 [r]	7,790 [r]	8,570 [r]	6,430 [r]	7,850	662 [9]	8.4
Boron minerals		3,620 [r]	4,200 [r]	4,480 [r]	3,760 [r]	4,080	W	NA
Bromine	metric tons	671,000 [r]	415,000 [r]	415,000 [r]	378,000 [r]	450,000	W [9]	NA
Celesite	do.	524,000 [r]	518,000 [r]	656,000 [r]	400,000 [r]	405,000	--	--
Cement, hydraulic		2,620,000 [r]	2,810,000 [r]	2,850,000 [r]	3,030,000 [r]	3,310,000	67,200 [10]	2.0
Clays:								
Bentonite		11,500 [r]	12,200 [r]	12,500 [r]	9,300 [r]	10,700	4,630	43.1
Fuller's earth		3,700 [r]	3,720 [r]	3,500 [r]	3,210 [r]	3,360	2,050	60.9
Kaolin		39,200 [r]	37,300 [r]	36,900 [r]	33,500 [r]	33,200	5,420	16.3
Diamond:								
Natural	thousand carats	175,000 [r]	170,000 [r]	154,000 [r]	131,000 [r]	144,000	--	--
Synthetic	do.	4,320,000 [r]	4,420,000 [r]	4,420,000 [r]	4,380,000 [r]	4,380,000	93,000 [e]	2.1
Diatomite		2,150 [r]	1,970 [r]	2,150 [r]	1,860 [r]	1,820	595 [9]	32.6
Feldspar		20,600 [r]	21,500 [r]	22,700 [r]	19,600 [r]	20,500	550 [11]	2.7
Fluorspar		5,660 [r]	5,730 [r]	6,000 [r]	5,550 [r]	6,010	--	--
Graphite, natural		1,020 [r]	1,110 [r]	960 [r]	760 [r]	930	--	--
Gypsum		160,000 [r]	167,000 [r]	156,000 [r]	150,000 [r]	147,000	8,840	6.0
Iodine, crude	metric tons	26,700 [r]	26,300 [r]	26,500 [r]	28,500 [r]	28,700	W	NA
Iron oxide pigments	do.	998,000 [r]	1,055,000 [r]	1,031,000 [r]	873,000 [r]	902,000	W	NA
Kyanite and related minerals	do.	455,000 [r]	515,000 [r]	448,000 [r]	396,000 [r]	469,000	133,000 [12]	28.4
Lime		285,000 [r]	296,000 [r]	307,000 [r]	297,000 [r]	311,000	18,300 [9, 10]	5.9
Lithium	metric tons	394,000	381,000	387,000	299,000 [r]	421,000	W	NA
Magnesite, crude[5]		14,400 [r]	20,300 [r]	21,500 [r]	18,200 [r]	19,900	W	NA
Mica, including scrap and flake[13]		1,090 [r]	1,120 [r]	1,140 [r]	1,020 [r]	1,070	53	4.9
Monazite concentrates	metric tons	6,850	6,860	6,430 [r]	6,230 [r]	6,230	--	--
Nitrogen, N content of ammonia		125,000 [r]	131,000 [r]	130,000 [r]	127,000 [r]	131,000	8,290 [14]	6.3
Peat		27,600 [r]	28,100 [r]	25,100 [r]	23,900 [r]	23,400	628 [15]	2.7
Perlite		1,800 [r]	1,760 [r]	1,780 [r]	1,650 [r]	1,670	410 [9]	24.8
Phosphate rock[3]		151,000	160,000	165,000	161,000 [r]	181,000	25,800	14.2
Potash, K_2O equivalent		30,400 [r]	34,900 [r]	33,700 [r]	20,600 [r]	33,700	930	2.8
Pumice		19,900 [r]	20,700 [r]	18,400 [r]	17,800 [r]	17,300	390 [9]	2.3
Rare earths	metric tons	137,000 [r]	124,000 [r]	128,000 [r]	132,000 [r]	124,000	--	--
Salt		261,000 [r]	266,000 [r]	276,000 [r]	279,000 [r]	280,000	43,300 [10]	15.5
Sand and gravel, industrial, silica		118,000 [r]	128,000 [r]	123,000 [r]	114,000 [r]	121,000	29,900 [9]	24.7
Soda ash, natural and manufactured		43,700 [r]	45,900 [r]	46,700 [r]	44,300 [r]	47,500	10,600 [16]	22.3
Sulfur, all forms		67,000 [r]	67,600 [r]	68,100 [r]	66,600 [r]	68,100	9,070	13.3
Talc and pyrophyllite[17]		7,770 [r]	7,730 [r]	7,590 [r]	7,230 [r]	7,210	604	8.4
Titanium concentrates:[3]								
Ilmenite and leucoxene		6,860 [r]	7,140 [r]	6,970 [r]	6,090 [r]	6,870	400 [e, 18]	5.8
Rutile[5]	metric tons	516,000 [r]	607,000 [r]	634,000 [r]	571,000 [r]	710,000	(19)	NA
Vermiculite	do.	512,000 [r]	510,000 [r]	525,000 [r]	509,000 [r]	536,000	100,000 [e]	18.7
Zirconium concentrates		1,240 [r]	1,410 [r]	1,310 [r]	1,180 [r]	1,250	W	NA

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in "World total." -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Primary.

[3] Gross weight.

[4] Individual country figures that are included in the world total represent dried bauxite equivalent of crude ore, but for some countries available insufficient to permit this adjustment.

TABLE 9—Continued

WORLD AND U.S. PRODUCTION OF SELECTED NONFUEL MINERAL COMMODITIES [1]

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[5] "World total" for years listed does not include U.S. production.

[6] U.S. production of mercury is byproduct only.

[7] Listed in molybdenum chapter (table 1) as production.

[8] Includes tin content of alloys made directly from ore.

[9] Quantity sold or used by producers.

[10] Includes Puerto Rico.

[11] Datum is rounded to no more than two significant digits.

[12] Includes synthetic mullite.

[13] Excludes, if any, U.S. production of low-quality sericite and sheet mica.

[14] Synthetic anhydrous ammonia; excludes coke oven byproduct ammonia.

[15] Horticultural use.

[16] U.S. production is natural only.

[17] Data for the United States exclude proprietary pyrophyllite production.

[18] Includes rutile to avoid disclosing company proprietary data. Rounded to one significant digit.

[19] Included with ilmenite to avoid disclosing company proprietary data; not included in "Total."

MINING AND QUARRYING TRENDS

By Mary E. Ewell

Domestic survey data were prepared by the author and the statistical assistants who have responsibility for the mineral commodities covered in this report.

The mining and quarrying trends shown in this report were calculated from nonfuel mineral data reported voluntarily to the U.S. Geological Survey (USGS) by mining and quarrying companies operating in the United States. The data for 2010 were reported on the "Mine, Development, and Mineral Exploration Supplement" statistical survey conducted by the USGS and on the production surveys for some more widely produced nonfuel mineral commodities, such as sand and gravel. Additional data for 2010 were derived from annual USGS production and consumption surveys of nonfuel mineral producers; these surveys accounted for 58 nonfuel mineral commodities produced in the United States. Nonfuel minerals do not include coal, petroleum coke, and related products.

The data in the following tables are reported according to the primary or principal product of a mine or operation; a product of lesser value is considered to be a byproduct. The primary product is the product with the highest total value for the year. In some instances, the values of two products at the same operation are so similar that the products are coproducts.

Total domestic mining and waste removal for nonfuel mineral materials production amounted to 4.94 billion metric tons (Gt) in 2010, a slight increase compared with the revised figure for 2009 (table 1). These materials included 3.64 Gt of crude ore mined or quarried and 1.30 Gt of mine ore and waste from development operations. Of the nonfuel mineral materials (ore and waste) removed, 51% was for the production of metals, and 49% was for the production of industrial minerals. Overall, 97% of nonfuel mineral materials was mined and quarried using surface methods, and 3% was mined underground.

Total surface mining, quarrying, and waste removal for industrial minerals production amounted to 2.28 Gt, virtually unchanged from the revised total for 2009. Crude ore mined at these surface operations was 2.08 Gt, and 205 million metric tons (Mt) was waste removed, including ore and waste from development operations. Underground mining for industrial minerals was only 129 Mt, nearly all of which was crude ore.

Total surface mining and waste removal to obtain metal ores amounted to 2.51 Gt, a slight increase compared with 2009 total. Of the 2.51 Gt, 1.42 Gt was crude ore mined, and 1.1 Gt was ore and waste from development operations. Underground mining of metal ores and waste removal amounted to 15 Mt, of which 87% was crude ore.

The 10 leading States in which mining for nonfuel mineral materials took place were, in descending order of total material handled, Nevada, Arizona, Texas, Minnesota, Florida, California, Pennsylvania, Michigan, Missouri, and Utah. (table 2). These 10 States accounted for 56% of the tonnage removed in the production of nonfuel mineral materials mined in the United States. Nearly all nonfuel mine production in these States was from surface operations.

TABLE 1

MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES, BY TYPE[1]

(Million metric tons)

	Surface[2]			Underground[3]			All mines		
Type of ore and year	Crude ore	Waste[4]	Total	Crude ore	Waste[4]	Total	Crude ore	Waste[4]	Total
Metals:									
2006	1,310	1,060	2,370	16	3	18 r	1,330	1,060	2,390
2007	1,370	1,120	2,500	19	3	22	1,390	1,130	2,520
2008	1,460	1,170	2,630	18 r	4	21	1,480	1,170	2,650
2009	1,360	1,140	2,500	13	1	15	1,380 r	1,140	2,520
2010	1,420	1,100	2,510	13	1	15	1,430	1,100	2,530
Industrial minerals:									
2006	3,130	266	3,400	129	(5)	129	3,260	267	3,520
2007	2,900	265	3,170	129	(5)	130 r	3,030	265	3,290
2008	2,520	251	2,770	150	1 r	151 r	2,670	252	2,920
2009	2,070 r	210	2,280 r	123	1	124 r	2,190 r	210	2,400 r
2010	2,080	205	2,280	128	1	129	2,210	206	2,410
All mineral commodities:									
2006	4,440	1,330	5,770	145	3	148	4,590	1,330	5,920
2007	4,270	1,390	5,660	148	3	151	4,420	1,390	5,810
2008	3,970	1,420	5,390	168	4	172	4,140	1,420	5,570
2009	3,430 r	1,350	4,780 r	136	2	138	3,570 r	1,350	4,920 r
2010	3,500	1,300	4,800	142	2	144	3,640	1,300	4,940

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes materials from wells, ponds, and pumping operations.

[3] Includes solution mining.

[4] Includes ore and waste from development operations.

[5] Less than ½ unit.

TABLE 2

MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2010, BY COMMODITY AND STATE[1]

Commodity or State	Number of mines[2]	Surface[3] Crude ore (thousand metric tons)	Surface[3] Waste[5] (thousand metric tons)	Surface[3] Total (thousand metric tons)	Underground[4] Crude ore (thousand metric tons)	Underground[4] Waste[5] (thousand metric tons)	Underground[4] Total (thousand metric tons)	All mines Crude ore (thousand metric tons)	All mines Waste[5] (thousand metric tons)	All mines Total (thousand metric tons)
Commodity:										
Metal ore:										
Copper[6]	18	608,000	244,000	852,000	--	--	--	608,000	244,000	852,000
Gold	38	287,000	594,000	881,000	5,320	W	5,320	292,000	594,000	886,000
Iron	13	165,000	151,000	316,000	--	--	--	165,000	151,000	316,000
Other[7]	29	357,000	107,000	465,000	8,120	1,310	9,430	366,000	109,000	474,000
Total	98	1,420,000	1,100,000	2,510,000	13,400	1,310	14,700	1,430,000	1,100,000	2,530,000
Industrial minerals:										
Clays	558	25,400	21,900	47,200	W	--	W	25,400	21,900	47,200
Gypsum	54	8,840	2,240	11,100	937	--	937	9,780	2,240	12,000
Feldspar[8]	12	546	--	546	--	--	--	546	--	546
Phosphate rock	12	106,000	W	106,000 [9]	--	--	--	106,000	W	106,000 [9]
Pumice[10]	14	390	W	390 [9]	--	--	--	390	W	390 [9]
Salt	60	8,650	--	8,650	34,800	--	34,800	43,500	--	43,500
Sand and gravel:										
Construction	6,489	795,000	--	795,000	--	--	--	795,000	--	795,000
Industrial	113	29,900	--	29,900	W	--	W	29,900 [11]	--	29,900 [11]
Soda ash	6	--	--	--	10,600	--	10,600	10,600	--	10,600
Stone:										
Crushed	3,953	1,090,000	77,800	1,160,000	68,700	538	69,200	1,160,000	78,300	1,230,000
Dimension	237	1,670	W	1,670 [9]	W	--	W	1,670 [11]	W	1,670 [9, 11]
Talc	6	604	W	604 [9]	--	--	--	604	W	604 [9]
Other[12]	86	13,900	104,000	117,000	13,500	4	13,500	27,400	104,000	131,000
Total	11,600	2,080,000	205,000	2,280,000	128,000	542	129,000	2,210,000	206,000	2,410,000
Grand total	11,698	3,500,000	1,300,000	4,800,000	142,000	1,850	144,000	3,640,000	1,300,000	4,940,000
State:										
Alabama	171	46,000	3,870	49,900	W	--	W	46,000 [11]	3,870	49,900 [11]
Alaska	111	28,900	W	28,900 [9]	W	--	W	28,900 [11]	W	28,900 [9, 11]
Arizona	321	534,000	W	534,000 [9]	W	W	W	534,000 [11]	W	534,000 [9, 11]
Arkansas	160	40,600	3,780	44,400	W	--	W	40,600 [11]	3,780	44,400 [11]
California	554	126,000	W	126,000 [9]	W	W	W	126,000 [11]	W	126,000 [9, 11]
Colorado	379	55,900	W	55,900 [9]	W	--	W	55,900 [11]	W	55,900 [9, 11]
Connecticut	105	13,000	657	13,700	--	--	--	13,000	657	13,700
Delaware	14	2,210	W	2,210 [9]	--	--	--	2,210	W	2,210 [9]
Florida	167	143,000	W	143,000 [9]	--	--	--	143,000	W	143,000 [9]
Georgia	226	53,500	8,820	62,300	W	W	W	53,500 [11]	8,820 [11]	62,300 [11]
Hawaii	42	5,320	351	5,670	--	--	--	5,320	351	5,670
Idaho	165	30,800	W	30,800 [9]	W	W	W	30,800 [11]	W	30,800 [9, 11]
Illinois	238	64,200	3,270	67,400	9,050	63	9,110	73,200	3,330	76,500
Indiana	237	53,200	3,330	56,600	W	W	W	53,200 [11]	3,330 [11]	56,600 [11]
Iowa	377	40,500	2,560	43,000	6,030	35	6,060	46,500	2,590	49,100

See footnotes at end of table.

TABLE 2—Continued
MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2010, BY COMMODITY AND STATE[1]

		Surface[3]			Underground[4]			All mines		
Commodity or State	Number of mines[2]	Crude ore (thousand metric tons)	Waste[5] (thousand metric tons)	Total (thousand metric tons)	Crude ore (thousand metric tons)	Waste[5] (thousand metric tons)	Total (thousand metric tons)	Crude ore (thousand metric tons)	Waste[5] (thousand metric tons)	Total (thousand metric tons)
State—Continued:										
Kansas	297	27,200	1,660	28,900	2,930	2	2,940	30,100	1,670	31,800
Kentucky	115	36,400	2,810	39,200	16,800	127	17,000	53,300	2,940	56,200
Louisiana	146	29,600	712	30,300	13,600	--	13,600	43,100	712	43,800
Maine	206	11,100	293	11,300	--	--	--	11,100	293	11,300
Maryland	77	29,500	1,650	31,200	W	W	W	29,500 [11]	1,650 [11]	31,200 [11]
Massachusetts	134	18,000	705	18,700	--	--	--	18,000	705	18,700
Michigan	496	93,000	W	93,000 [9]	W	--	W	93,000 [11]	W	93,000 [9,11]
Minnesota	441	168,000	W	168,000	--	--	--	168,000	W	168,000
Mississippi	108	15,800	606	16,400	--	--	--	15,800	606	16,400
Missouri	317	71,600	5,550	77,200	14,500	954	15,500	86,100	6,500	92,600
Montana	272	28,200	W	28,200 [9]	W	W	W	28,200	W	28,200 [9,11]
Nebraska	184	16,300	278	16,600	W	W	W	16,300 [11]	278 [11]	16,600 [11]
Nevada	202	610,000	609,000	1,220,000	W	W	W	610,000 [11]	609,000 [11]	1,220,000 [11]
New Hampshire	121	10,000	308	10,300	--	--	--	10,000	308	10,300
New Jersey	81	23,600	1,010	24,600	--	--	--	23,600	1,010	24,600
New Mexico	188	55,200	451	55,600	W	--	W	55,200 [11]	451	55,600 [11]
New York	519	62,200	3,310	65,500	6,270	W	6,270 [11]	68,400	3,310 [11]	71,700 [11]
North Carolina	263	57,900	6,450	64,400	--	--	--	57,900	6,450	64,400
North Dakota	203	17,800	W	17,800 [9]	--	--	--	17,800	W	17,800 [9]
Ohio	331	67,600	3,510	71,100	6,310	W	6,310 [11]	73,900	3,510 [11]	77,400 [11]
Oklahoma	170	52,400	3,460	55,800	W	W	W	52,400 [11]	3,460 [11]	55,800 [11]
Oregon	298	26,500	1,100	27,600	--	--	--	26,500	1,100	27,600
Pennsylvania	381	80,500	5,630	86,100	8,330	60	8,390	88,800	5,690	94,500
Rhode Island	20	2,450	68	2,510	--	--	--	2,450	68	2,510
South Carolina	110	24,600	1,490	26,100	--	--	--	24,600	1,490	26,100
South Dakota	146	25,000	W	25,000 [9]	--	--	--	25,000	W	25,000 [9]
Tennessee	181	43,500	3,510	47,000	2,750	W	2,750 [11]	46,200	3,510 [11]	49,700 [11]
Texas	603	184,000	10,600	194,000	8,660	W	8,660 [11]	192,000	10,600 [11]	203,000 [11]
Utah	267	89,700	W	89,700 [9]	W	--	W	89,700 [11]	W	89,700 [9,11]
Vermont	159	10,600	488	11,100	--	--	--	10,600	488	11,100
Virginia	172	57,200	3,940	61,200	W	W	W	57,200 [11]	3,940 [11]	61,200 [11]
Washington	323	41,000	1,100	42,100	W	W	W	41,000 [11]	1,100 [11]	42,100 [11]
West Virginia	42	12,600	995	13,600	W	W	W	12,600 [11]	995 [11]	13,600 [11]
Wisconsin	566	49,800	1,760	51,600	W	--	W	49,800 [11]	1,760	51,600 [11]
Wyoming	292	26,600	4,240	30,800	9,710	--	9,710	36,300	4,240	40,500
Undistributed[13]	--	83,600	599,000	683,000	37,000	611	37,600	121,000	600,000	720,000
Total	11,698	3,500,000	1,300,000	4,800,000	142,000	1,850	144,000	3,640,000	1,300,000	4,940,000

W Withheld to avoid disclosing company proprietary data; included with "Other" or "Undistributed." -- Zero.

[1] Data are rounded to no more than three significant digits except "number of mines"; may not add to totals shown.

[2] Includes quarries and other mineral operations.

[3] Includes materials from wells, ponds, and pumping operations.

[4] Includes solution mining.

TABLE 2—Continued
MATERIAL HANDLED AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2010, BY COMMODITY AND STATE[1]

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[5] Includes ore and waste from development operations.

[6] Includes copper-molybdenum. With increased adoption of leaching technology, there may be less distinction between ore and waste. Significant tonnages of low-grade material, formerly classified as waste, are now considered to be low-grade leachable ore by some companies, resulting in a large shift in the ore-to-waste ratios and a reduction in ore value; see data in table 3.

[7] Includes beryllium, gold-silver, lead, magnesium metal, molybdenum, platinum and palladium, silver, titanium, uranium, zinc, zinc-lead, and zinc-silver.

[8] Includes aplite.

[9] Excludes waste from mining operations and ore and waste from development operations.

[10] Excludes volcanic cinder and scoria; included with "Crushed stone."

[11] Excludes materials from underground operations.

[12] Includes abrasives, barite, boron minerals, bromine, diatomite, emery, garnet, greensand marl, iodine, iron oxide pigments, kyanite, lithium minerals, magnesite, magnesium compounds, mica, olivine, perlite, potash, tripoli, vermiculite, wollastonite, zeolites, and industrial minerals indicated by symbol W.

[13] Includes material from States indicated by symbol W.

TABLE 3
VALUE OF PRINCIPAL MINERAL PRODUCTS AND BYPRODUCTS OF SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2010[1]

(Dollars per metric ton)

	Surface			Underground			All mines		
Commodity	Principal mineral product	Byproduct	Total	Principal mineral product	Byproduct	Total	Principal mineral product	Byproduct	Total
Metal ore:									
Gold	39.47	W	39.47 [2]	W	W	W	39.47 [3]	W	39.47 [2,3]
Copper[4]	7.68	W	7.68 [2]	--	--	--	7.68	W	7.68 [2]
Iron	98.79 [5]	--	98.79 [5]	--	--	--	98.79 [5]	--	98.79 [5]
Average, metals[6]	26.40	W	26.40 [2]	274.37	35.00	309.37	29.76	3.82	33.58
Industrial minerals:									
Clays	57.56	--	57.56	W	--	W	57.56	--	57.56 [3]
Feldspar[7]	61.40	--	61.40	--	--	--	61.40	--	61.40
Gypsum	6.89	--	6.89	W	--	W	6.89	--	6.89 [3]
Phosphate rock	76.69 [8]	--	76.69 [8]	--	--	--	76.69 [8]	--	76.69 [8]
Pumice[9]	20.00	--	20.00	--	--	--	20.00	--	20.00
Salt	W	--	W	35.92 [5]	--	35.92 [5]	35.92 [5, 10]	--	35.92 [5, 10]
Sand and gravel:									
Construction	7.31	--	7.31	--	--	--	7.31	--	7.31
Industrial	34.58	--	34.58	W	--	W	34.58 [3]	--	34.58 [3]
Soda ash	--	--	--	128.39	W	128.39 [2]	128.39	--	128.39
Stone:									
Crushed	9.67	--	9.67	9.67	--	9.67	9.67	--	9.67
Dimension	193.63	--	193.63	W	--	W	193.63 [3]	--	193.6 [3]
Talc	31.62	--	31.62	--	--	--	31.62	--	31.62
Average, industrial minerals[11]	11.04	0.07	11.11	28.99	W	28.99	12.13	0.07	12.20
Average, industrial minerals, excluding sand and gravel and stone[11]	33.73	0.30	34.03	53.11	W	53.11	38.71	0.22	38.93
Average, metals and industrial minerals[6, 11]	16.12	1.17	17.29	52.35	3.33	55.68	17.77	1.27	19.04
Average, metals and industrial minerals, excluding sand and gravel and stone[6, 11]	27.41	2.97	30.38	97.31	6.99	104.30	31.32	3.19	34.51

W Withheld to avoid disclosing company proprietary data; included in appropriate "Average." -- Zero.

[1] Values calculated from unrounded data; may not add to totals shown because of independent rounding.

[2] Value of principal mineral product only.

[3] Value of products at surface operations only.

[4] Includes copper-molybdenum. With increased adoption of leaching technology, there may be less distinction between ore and waste. Significant tonnages of low-grade material, formerly classified as waste, are now considered to be low-grade leachable ore by some companies, resulting in a large shift in the ore-to-waste ratios and a reduction in ore value.

[5] Average value at mines only.

[6] Includes beryllium, gold-silver, lead, magnesium metal, molybdenum, platinum and palladium, silver, titanium, uranium, zinc, zinc-lead, zinc-silver, and metals indicated by symbol W.

[7] Includes aplite.

[8] Average value based on the sold or used values.

[9] Excludes volcanic cinder and scoria; included with "Crushed stone."

[10] Value of products at underground operations only.

[11] Includes values of abrasives, barite, boron minerals, bromine, diatomite, emery, garnet, greensand marl, iodine, iron oxide pigments, kyanite, lithium minerals, magnesite, magnesium compounds, mica, olivine, perlite, potash, tripoli, vermiculite, wollastonite, zeolites, and industrial minerals indicated by symbol W.

TABLE 4
TWENTY-FIVE LEADING METAL AND INDUSTRIAL MINERAL MINES AND QUARRIES IN THE UNITED STATES IN 2010, IN ORDER OF OUTPUT OF CRUDE ORE[1]

Name of mine, quarry or operation[2]	State	Operator	Commodity	Mining method
Metal:				
Eastern Nevada operations[3]	Nevada	Newmont Mining Corp.	Gold	Open pit and underground.
Morenci	Arizona	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum	Open pit.
Goldstrike[4]	Nevada	Barrick Gold Corp.	Gold	Open pit and underground.
Cortez[5]	do.	do.	do.	Open pit.
Bagdad	Arizona	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum	Do.
Mission Complex	do.	ASARCO LLC[6]	do.	Do.
Smoky Valley Common Operation	Nevada	Kinross Gold Corp.	Gold	Do.
Sierrita	Arizona	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum	Do.
Safford	do.	do.	Copper	Do.
Bingham Canyon	Utah	Kennecott Utah Copper Corp.[7]	Copper-molybdenum	Do.
Minntac	Minnesota	United States Steel Corp.	Iron ore	Do.
Ray	Arizona	ASARCO LLC[6]	Copper	Do.
Bald Mountain	Nevada	Barrick Gold Corp.	Gold	Do.
Tyrone	New Mexico	Freeport-McMoRan Copper & Gold Inc.	Copper	Do.
Tilden	Michigan	Cliffs Natural Resources Inc.	Iron ore	Do.
Ruby Hill	Nevada	Barrick Gold Corp.	Gold	Do.
Marigold	do.	Goldcorp Inc.	do.	Do.
Hibbing Taconite	Minnesota	Cliffs Natural Resources Inc.	Iron ore	Do.
Cresson	Colorado	AngloGold Ashanti Ltd.	Gold	Do.
Fort Knox	Alaska	Kinross Gold Corp.	do.	Do.
Keetac	Minnesota	United States Steel Corp.	Iron ore	Do.
Continental Pit	Montana	Montana Resources	Copper-molybdenum	Do.
United Taconite	Minnesota	Cliffs Natural Resources Inc.	Iron ore	Do.
Northshore	do.	do.	do.	Do.
Empire	Michigan	do.	do.	Do.
Industrial mineral:				
Florida mines (five)	Florida	The Mosaic Co.	Phosphate rock	Do.
South Pasture	do.	CF Industries, Inc.	do.	Do.
Swift Creek	do.	PCS Phosphate Co., Inc.	do.	Do.
Beckmann	Texas	Martin Marietta Aggregates	Stone, crushed	Quarry.
Aurora	North Carolina	PCS Phosphate Co., Inc.	Phosphate rock	Open pit.
Balcones Plant	Texas	CEMEX S.A.B. de C.V.	Stone, crushed	Quarry.
Peerless Mine	Missouri	Mississippi Lime Co.	do.	Underground.
Ste. Genevieve Quarry	do.	Tower Rock Stone Co.	do.	Quarry.
White Rock	Florida	Vecellio & Grogan, Inc.	do.	Do.
Georgetown	Texas	Texas Crushed Stone Co., Inc.	do.	Do.
Perch Hill 74	do.	Lehigh Hanson, Inc.	do.	Do.
Washington Plants (five)	Washington	Eucon Corp.	do.	Do.
Cape Sandy	Indiana	Mulzer Crushed Stone Co., Inc.	do.	Do.
Macon Quarry	Georgia	Ready Mix USA Holding Co.	do.	Do.
Three Rivers Quarry	Kentucky	Martin Marietta Aggregates	do.	Do.
Richards	Oklahoma	The Dolese Brothers Co.	do.	Do.
Ste. Genevieve Quarry	Missouri	Holcim Group/Aggregate Industries Management, Inc.	do.	Do.
Freeport	Texas	Dow Chemical Co.	Salt	Solution.
Ogden	Utah	Great Salt Lake Minerals Corp.	Magnesium compounds	Well and pumping.
Hunter Quarry	Texas	Hunter Industries, Inc.	Stone, crushed	Quarry.
McCook 378	Illinois	Vulcan Materials Co.	do.	Do.
TXI Mill Creek Quarry	Texas	Texas Industries, Inc.	do.	Do.
Maysville	Kentucky	Carmeuse Inc.	do.	Quarry and underground.
Hatton Quarry	Arkansas	Martin Marietta Aggregates	do.	Quarry.
Hampton Corners	New York	American Rock Salt Co.	Salt	Solution.

Do., do. Ditto.

[1] List includes private-sector operations only; excludes U.S. Bureau of Land Management and U.S. Forest Service operations.

[2] Where data are not reported for individual mining operations, ranking is on the basis of production as reported for a group of operations.

[3] Includes Carlin Mines complex, Carlin East Mine, Deep Post Mine, Gold Quarry Mine, Leeville Mine, Midas Mine, Pete Mine, Phoenix Mine, Twin Creeks Mine, and Turquoise Ridge Mine; ore was mined from eight open pits and six underground mines.

TABLE 4—Continued
TWENTY-FIVE LEADING METAL AND INDUSTRIAL MINERAL MINES AND QUARRIES IN THE UNITED STATES IN 2010, IN ORDER OF OUTPUT OF CRUDE ORE[1]

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[4] Formerly listed as Betze-Post Mine.

[5] Includes Cortez Hills and Cortez Pipeline Mines.

[6] Wholly owned subsidiary of Grupo Mexico, S.A.B. de C.V.

[7] Wholly owned subsidiary of Rio Tinto plc.

TABLE 5
TWENTY-FIVE LEADING METAL AND INDUSTRIAL MINERAL MINES AND QUARRIES IN THE UNITED STATES IN 2010, IN ORDER OF OUTPUT OF TOTAL MATERIAL HANDLED[1]

Name of mine, quarry or operation[2]	State	Operator	Commodity	Mining method
Metal:				
Eastern Nevada operations[3]	Nevada	Newmont Mining Corp.	Gold	Open pit and underground.
Goldstrike[4]	do.	Barrick Gold Corp.	do.	Do.
Cortez[5]	do.	do.	do.	Open pit.
Bingham Canyon	Utah	Kennecott Utah Copper Corp.[6]	Copper-molybdenum	Do.
Morenci	Arizona	Freeport-McMoRan Copper & Gold Inc.	do.	Do.
Smoky Valley Common Operation	Nevada	Kinross Gold Corp.	Gold	Do.
Minntac	Minnesota	United States Steel Corp.	Iron ore	Do.
Ray	Arizona	ASARCO LLC[7]	Copper	Do.
Bald Mountain	Nevada	Barrick Gold Corp.	Gold	Do.
Marigold	do.	Goldcorp Inc.	do.	Do.
Bagdad	Arizona	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum	Do.
Tilden	Michigan	Cliffs Natural Resources Inc.	Iron ore	Do.
Cresson	Colorado	AngloGold Ashanti Ltd.	Gold	Do.
Mission Complex	Arizona	ASARCO LLC[7]	Copper-molybdenum	Do.
Sierrita	do.	Freeport-McMoRan Copper & Gold Inc.	do.	Do.
Safford	do.	Freeport-McMoRan Copper & Gold Inc.	Copper	Do.
Robinson	Nevada	Quadra Mining Ltd.	Copper-molybdenum	Do.
Mesquite	California	New Gold Inc.	Gold	Do.
Ruby Hill	Nevada	Barrick Gold Corp.	do.	Do.
Hibbing Taconite	Minnesota	Cliffs Natural Resources Inc.	Iron ore	Do.
Keetac	do.	United States Steel Corp.	do.	Do.
United Taconite	do.	Cliffs Natural Resources Inc.	do.	Do.
Fort Knox	Alaska	Kinross Gold Corp.	Gold	Do.
Northshore	Minnesota	Cliffs Natural Resources Inc.	Iron ore	Do.
Golden Sunlight	Montana	Barrick Gold Corp.	Gold	Do.
Industrial mineral:				
Florida mines (five)	Florida	The Mosaic Co.	Phosphate rock	Do.
Boron Mine	California	U.S. Borax Inc.	Boron	Do.
South Pasture	Florida	CF Industries, Inc.	Phosphate rock	Do.
Swift Creek	do.	PCS Phosphate Co., Inc.	do.	Do.
Aurora	North Carolina	do.	do.	Do.
Beckmann	Texas	Martin Marietta Aggregates	Stone, crushed	Quarry.
Balcones Plant	do.	CEMEX S.A.B. de C.V.	do.	Do.
Ste. Genevieve Quarry	Missouri	Tower Rock Stone Co.	do.	Do.
Peerless Mine	do.	Mississippi Lime Co.	do.	Underground.
White Rock	Florida	Vecellio & Grogan, Inc.	do.	Quarry.
Georgetown	Texas	Texas Crushed Stone Co., Inc.	do.	Do.
Perch Hill 74	do.	Lehigh Hanson, Inc.	do.	Do.
Washington Plants (five)	Washington	Eucon Corp.	do.	Do.
Cape Sandy	Indiana	Mulzer Crushed Stone Co., Inc.	do.	Do.
Macon Quarry	Georgia	Ready Mix USA Holding Co.	do.	Do.
Three Rivers Quarry	Kentucky	Martin Marietta Aggregates	do.	Do.
Richards	Oklahoma	The Dolese Brothers Co.	do.	Do.
Ste. Genevieve Quarry	Missouri	Holcim Group/Aggregate Industries Management, Inc.	do.	Do.

See footnotes at end of table.

TABLE 5—Continued

TWENTY-FIVE LEADING METAL AND INDUSTRIAL MINERAL MINES AND QUARRIES IN THE UNITED STATES IN 2010, IN ORDER OF OUTPUT OF TOTAL MATERIAL HANDLED[1]

Name of mine, quarry or operation[2]	State	Operator	Commodity	Mining method
Industrial mineral—Continued:				
Hunter Quarry	Texas	Hunter Industries, Inc.	Stone, crushed	Quarry.
McCook 378	Illinois	Vulcan Materials Co.	do.	Do.
TXI Mill Creek Quarry	Texas	Texas Industries, Inc.	do.	Do.
Freeport	do.	Dow Chemical Co.	Salt	Solution.
Ogden	Utah	Great Salt Lake Minerals Corp.	Magnesium compounds	Well and pumping.
Maysville	Kentucky	Carmeuse Inc.	Stone, crushed	Quarry.
Hatton Quarry	Arkansas	Martin Marietta Aggregates	do.	Do.

Do., do. Ditto.

[1] List includes private-sector operations only; excludes U.S. Bureau of Land Management and U.S. Forest Service operations.

[2] Where data are not reported for individual mining operations, ranking is on the basis of production as reported for a group of operations.

[3] Includes Carlin Mines complex, Carlin East Mine, Deep Post Mine, Gold Quarry Mine, Leeville Mine, Midas Mine, Pete Mine, Phoenix Mine, Twin Creeks Mine, and Turquoise Ridge Mine; ore was mined from eight open pits and six underground mines.

[4] Formerly listed as Betze-Post Mine.

[5] Includes Cortez Hills and Cortez Pipeline Mines.

[6] Wholly owned subsidiary of Rio Tinto plc.

[7] Wholly owned subsidiary of Grupo Mexico, S.A.B. de C.V.

TABLE 6
MARKETABLE PRODUCT AND ORE TREATED OR SOLD AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2010, BY SELECTED COMMODITY AND STATE[1]

(Thousand metric tons, unless otherwise specified)

	Marketable product			Ore treated or sold		
Commodity or State	Surface	Underground	Total	Surface	Underground	Total
Commodity:						
Metal ore:						
Copper[2]	1,110	--	1,110	609,000	--	609,000
Gold	(3)	(3)	231,000 [4]	183,000	5,350	188,000
Iron ore, usable	49,900	--	49,900	165,000	--	165,000
Industrial minerals:						
Clays	25,400	(5)	25,400	25,400	(6)	25,400
Feldspar[7]	546	--	546	546	--	546
Gypsum	8,840	2,240	11,100	8,840	2,240	11,100
Phosphate rock	25,800	--	25,800	106,000	--	106,000
Pumice[8]	390	--	390	390	--	390
Salt	(9)	43,500	43,500	(10)	43,300	43,300
Sand and gravel:						
Construction	795,000	--	795,000	795,000	--	795,000
Industrial	29,900	(5)	29,900	29,900	(6)	29,900
Soda ash	--	10,600	10,600	--	10,600	10,600
Stone:						
Crushed	1,090,000	68,700	1,160,000	1,090,000	68,700	1,160,000
Dimension	1,670	(5)	1,670	1,670	(10)	1,670
Talc	511	--	511	511	--	511
State:						
Alabama	46,400	(5)	46,400	46,400	(6)	46,400
Alaska	8,100	(5)	8,100	37,300	(6)	37,300
Arizona	42,600	--	42,600	515,000	(6)	515,000
Arkansas	41,500	(5)	41,500	41,500	(6)	41,500
California	108,000	(5)	108,000	138,000	(6)	138,000
Colorado	36,400	(5)	36,400	57,000	(6)	57,000
Connecticut	13,000	--	13,000	13,000	--	13,000
Delaware	2,210	--	2,210	2,210	--	2,210
Florida	143,000	--	143,000	143,000	--	143,000
Georgia	53,500	(5)	53,500	53,500	(6)	53,500
Hawaii	5,320	--	5,320	5,320	--	5,320
Idaho	21,300	(5)	21,300	31,600	(6)	31,600
Illinois	65,900	9,050	75,000	65,900	9,050	75,000
Indiana	60,900	(5)	60,900	60,900	(6)	60,900
Iowa	41,500	6,030	47,500	41,500	6,030	47,500
Kansas	27,300	2,870	30,200	27,300	2,870	30,200
Kentucky	37,400	16,800	54,200	37,400	16,800	54,200
Louisiana	28,500	13,300	41,800	29,600	13,900	43,500
Maine	11,100	--	11,100	11,100	--	11,100
Maryland	29,700	(5)	29,700	29,700	(6)	29,700
Massachusetts	18,000	--	18,000	18,000	--	18,000
Michigan	69,100	(5)	69,100	96,000	(6)	96,000
Minnesota	80,300	--	80,300	168,000	--	168,000
Mississippi	16,100	--	16,100	16,100	--	16,100
Missouri	71,600	10,100	81,800	71,600	14,500	86,100
Montana	12,700	(5)	12,700	30,600	(6)	30,600
Nebraska	20,600	(5)	20,600	20,600	(6)	20,600
Nevada	24,200	(5)	24,200	153,000	(6)	153,000
New Hampshire	10,100	--	10,100	10,100	--	10,100
New Jersey	25,100	--	25,100	25,100	--	25,100
New Mexico	18,500	(5)	18,500	61,000	(6)	61,000
New York	62,100	6,200	68,300	62,100	6,200	68,300
North Carolina	53,100	--	53,100	58,000	--	58,000
North Dakota	17,900	--	17,900	17,900	--	17,900
Ohio	67,800	6,410	74,200	67,800	6,410	74,200

See footnotes at end of table.

TABLE 6—Continued
MARKETABLE PRODUCT AND ORE TREATED OR SOLD AT SURFACE AND UNDERGROUND MINES IN THE UNITED STATES IN 2010, BY SELECTED COMMODITY AND STATE[1]

(Thousand metric tons, unless otherwise specified)

	Marketable product			Ore treated or sold		
Commodity or State	Surface	Underground	Total	Surface	Underground	Total
State—Continued:						
Oklahoma	50,400	(5)	50,400	52,800	(6)	52,800
Oregon	26,800	--	26,800	26,800	–	26,800
Pennsylvania	80,800	8,330	89,100	80,800	8,330	89,100
Rhode Island	2,450	--	2,450	2,450	--	2,450
South Carolina	24,700	--	24,700	24,700	–	24,700
South Dakota	15,800	--	15,800	25,200	–	25,200
Tennessee	43,800	2,760	46,500	43,800	2,760	46,500
Texas	184,000	8,440	192,000	184,000	8,660	193,000
Utah	35,100	(5)	35,100	89,300	(6)	89,300
Vermont	10,600	--	10,600	10,600	–	10,600
Virginia	53,500	(5)	53,500	56,400	(6)	56,400
Washington	41,300	(5)	41,300	41,700	(6)	41,700
West Virginia	16,200	(5)	16,200	16,200	(6)	16,200
Wisconsin	51,100	(5)	51,100	51,100	(6)	51,100
Wyoming	26,900	9,710	36,600	26,900	9,710	36,600

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes copper-molybdenum.

[3] Withheld to avoid disclosing company proprietary data; included in "Marketable product, total."

[4] Kilograms.

[5] Withheld to avoid disclosing company proprietary data; included in "Marketable product, surface."

[6] Withheld to avoid disclosing company proprietary data; included in "Ore treated or sold, surface."

[7] Includes aplite.

[8] Excludes volcanic cinder and scoria; included with "Crushed stone."

[9] Withheld to avoid disclosing company proprietary data; included in "Marketable product, underground."

[10] Withheld to avoid disclosing company proprietary data; included in "Ore treated or sold, underground."

TABLE 7
MINING METHODS USED AT SURFACE OPERATIONS IN THE UNITED STATES IN 2010, BY COMMODITY

(Percentage of total material handled)

Commodity	Preceded by drilling and blasting	Not preceded by drilling and blasting[1]
Metal ore:		
Beryllium	100	--
Copper[2]	98	2
Gold[3]	85	15
Iron	95	5
Magnesium metal	--	100
Molybdenum	100	--
Titanium	--	100
Uranium	--	100
Zinc	100	--
Industrial minerals:		
Abrasives	100	--
Barite	32	68
Boron minerals	100	--
Bromine	43	57
Clays	5	95
Diatomite	37	63
Emery	100	--
Feldspar[4]	94	6
Garnet	40	60
Greensand marl	--	100
Gypsum	100	--
Iodine	--	100
Iron oxide pigments	--	100
Kyanite	100	--
Lithium minerals	--	100
Magnesite	100	--
Magnesium compounds	--	100
Mica, scrap	51	49
Olivine	100	--
Perlite	30	70
Phosphate rock	4	96
Potash	--	100
Pumice[5]	19	81
Salt	--	100
Sand and gravel:		
Construction	--	100
Industrial	--	100
Stone:		
Crushed	100	--
Dimension	--	100
Talc	98	2
Tripoli	84	16
Vermiculite	34	66
Wollastonite	83	17
Zeolites	99	1

-- Zero.

[1] Includes drilling and cutting without blasting, dredging, mechanical excavation and nonfloat washing, and other surface mining methods.

[2] Includes copper-molybdenum.

[3] Includes gold-silver.

[4] Includes aplite.

[5] Excludes volcanic cinder and scoria; included with "Crushed stone."

TABLE 8
EXPLORATION ACTIVITY IN THE UNITED STATES IN 2010, BY METHOD, COMMODITY, AND STATE[1]

(Meters)

Commodity or State	Churn and diamond drilling	Rotary and reverse circulation drilling	Percussion drilling, other drilling, and trenching	Grand total
Commodity:				
Copper[2]	47,000	4,880	W	51,800
Gold	234,000	835,000	W	1,070,000
Lead	27,500	35,400	--	62,900
Zinc	9,330	--	--	9,330
Other[3]	16,800	124,000	29,000	170,000
Total	335,000	1,000,000	29,000	1,360,000
Percentage of grand total	25	73	2	100
State:				
Alaska	21,600	276,000	W	298,000
Arizona	24,200	4,880	--	29,000
Missouri	27,500	35,400	--	62,900
Nebraska	--	76,200	--	76,200
Nevada	222,000	558,000	W	779,000
Washington	9,330	--	--	9,330
Undistributed[4]	30,300	49,700	29,000	109,000
Total	335,000	1,000,000	29,000	1,360,000

W Withheld to avoid disclosing company proprietary data; included with "Other" or "Undistributed." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes copper-molybdenum.

[3] Includes cobalt, mica, platinum and palladium, rare earths, silver, talc, and uranium, and commodities indicated by symbol W.

[4] Includes Alabama, California, Idaho, Montana, Texas, Washington, Wyoming, and States indicated by symbol W.

ABRASIVES, MANUFACTURED

By Donald W. Olson

Domestic survey data and tables were prepared by Glenn W. Walker, statistical assistant.

In 2010, estimated Canadian and United States combined production of regular-grade fused aluminum oxide was 10,000 metric tons (t), with a value estimated to be $1.7 million. The U.S. apparent consumption of fused aluminum oxide was estimated to be 131,000 t. U.S. silicon carbide production was estimated to be 35,000 t, with an estimated value of $25.9 million. The U.S. apparent consumption of crude silicon carbide was estimated to be 116,000 t. U.S. production of metallic abrasives was 169,000 t valued at $89.1 million. U.S. shipments of metallic abrasives were 187,000 t, with a value of $117 million. The U.S. apparent consumption of metallic abrasives was estimated to be 199,000 t.

This report includes information on the following abrasives manufactured in the United States: aluminum-zirconium oxide, boron carbide, fused aluminum oxide, metallic shot and grit, and silicon carbide. In some cases, United States production data were combined with Canadian output to avoid disclosing company proprietary data and still provide useful data on the overall Canadian–United States market. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using the unrounded data.

Abrasives play an important role in the fashioning and finishing of many products with a wide range of uses. Abrasives are natural or manufactured substances that are used to abrade, clean, etch, grind, polish, scour, or otherwise remove solid material by rubbing action (as in a grinding wheel) or impact (as in pressure blasting). The most important physical properties for abrasives are character of fracture (cleavage), friability, grain shape and size, hardness (scratch hardness), purity (uniformity), and toughness (rigidity). Additional considerations include availability, bonding characteristics, cost, and thermal stability. Manufactured abrasives are made from metals or minerals by heating or chemically treating them to enhance or give them abrasive properties. No single property is paramount for any use (Wellborn, 1996, p. 31, 43).

Manufactured abrasives generally dominate high-grade abrasives markets as opposed to natural abrasives because they have superior physical properties, more uniform quality, and can be tailored to meet users' needs. Consequently, manufactured abrasives typically are characterized by premium prices relative to natural abrasive minerals. Even though manufactured abrasives are usually more expensive, their durability and efficiency have proven to be more cost effective. They are preferred in many industrial applications, such as metal finishing, cutting, and polishing. In the United States, large volumes of abrasives also are used in cutting and finishing wallboard and timber. The abrasives market is mature, and the use of various manufactured abrasive materials is fairly well defined by application (Kendall, 2001, p. 55).

Fused Aluminum Oxide

Production.—Production data for regular and high-purity fused aluminum oxide in this report were obtained by the U.S. Geological Survey (USGS) from producers in Canada and the United States. The data were collected from two companies that operated three plants and represented the entire Canadian and United States fused aluminum oxide industry (table 1). Saint-Gobain Abrasives operated a fused aluminum oxide plant in the United States, and Washington Mills Electro Minerals Corp. operated fused aluminum oxide plants in Canada and the United States. Quantity data from the two countries were combined to avoid disclosing company proprietary data and are reported by the producers, estimated, and rounded to the nearest 5,000 t.

Production of regular-grade fused aluminum oxide in 2010 was an amount rounded to 10,000 t, with a value rounded to $1.7 million. The weight and value were essentially unchanged compared with 2009 regular-grade fused aluminum oxide production (table 2). Reporting on the output of high-purity fused aluminum oxide has been discontinued to avoid disclosing company proprietary data.

Consumption.—Abrasive-grade fused aluminum oxide has many end uses. Specific applications in 2010 included antislip additives, bonded abrasives (such as abrasive grains that are made to adhere to each other and then are pressed or molded into abrasive tools), buffing/polishing compounds, coated abrasives (such as abrasive grains glued to a backing of paper or cloth), dry or wet blasting media, and tumbling media. Fused aluminum oxide in a micropowder form was used for industrial and electronic applications that require fine surface finishing. Fused aluminum oxide does not face any significant substitution threats at present, as it is generally a very cost-effective abrasive. The total 2010 U.S. apparent consumption of all forms of fused aluminum oxide was estimated to be 131,000 t, with a value of $72.5 million, based on the average customs unit value for imports.

Prices.—The USGS canvassed fused aluminum oxide producers to determine the total value of their production for the year. The survey indicated that the average unit value of regular fused aluminum oxide produced in Canada during 2010 was $165 per metric ton at the point of production; the average value of high-purity fused aluminum oxide output was $671 per ton at the point of production. Prices of abrasive grain produced from these materials and sold to consumers were significantly higher.

Average unit values of fused aluminum oxide traded by the United States in 2010 as reported in this publication are based on U.S. Census Bureau data. The average value for U.S. exports of crude fused aluminum oxide during the year was about $3,400 per ton. The average customs value of crude fused aluminum oxide imports during the year was $555 per ton, but values ranged from $210 per ton (Germany) to $9,590 per ton (Republic of Korea), and those of fused aluminum oxide grain imports averaged $1,300 per ton and ranged from $481 per ton (United Kingdom) to $6,700 per ton (Slovakia). The extremely high values represent small quantities of highly specialized materials.

Foreign Trade.—Compared with those of the previous year, crude fused aluminum oxide exports in 2010 increased by 62% to 20,000 t, and the value of those exports increased by 112% to $67.9 million (table 5). Of the exports shipped to 39 countries, 78% went to Canada, Germany, Mexico, and the United Kingdom, in decreasing order by quantity.

During 2010, imports of crude fused aluminum oxide were received from 12 countries and increased by 268% to 141,000 t valued at $78.1 million compared with those of 2009; imports of ground and refined fused aluminum oxide were received from 22 countries and increased by 71% to 44,600 t valued at $58.0 million (table 6). Some of the imported crude fused aluminum oxide was refractory-grade material. China, Venezuela, and Canada supplied 77%, 15%, and 5%, respectively, of the crude imports. Compared with those of 2009, crude imports from Canada decreased to 7,180 t from 8,450 t, while imports from China increased to 108,000 t from 24,200 t, and those from Venezuela increased to 20,400 t from 5,090 t. Brazil, Germany, Austria, China, Hungary, and Italy provided 32%, 23%, 18%, 9%, 6%, and 4%, respectively, of the ground and refined material.

These relatively large increases in the quantities and values of aluminum oxide exports and imports are because of the improvement of global economic conditions during 2010 and its impact on industries that use aluminum oxide.

Silicon Carbide

Production.—One company produced abrasive-grade silicon carbide in the United States during 2010 (table 1). This company also produced similar amounts of metallurgical-grade silicon carbide. A second company, in Hopkinsville, KY, produced a small quantity of silicon carbide, primarily intended for use in heat-resistant products rather than abrasives. U.S. silicon carbide production decreased slightly during 2010 to an estimated 35,000 t, and the value of production decreased slightly to $25.9 million (table 2).

Consumption.—Abrasive-grade silicon carbide has many end uses. Specific applications in 2010 included antislip abrasives, blasting abrasives, bonded abrasives, coated abrasives, polishing/buffing compounds, tumbling media, and wiresawing abrasives. The total abrasive-grade silicon carbide consumed in the United States in 2010 was about 116,000 t with a value of $92.0 million, based on the average customs unit value for imports.

Prices.—Based on information from industry sources and publications, the average value of abrasive-grade silicon carbide at the point of manufacture was $739 per ton in 2010, which was unchanged compared with that of 2009. The average value for U.S. crude silicon carbide exports in 2010 was $1,460 per ton, a 5% decrease compared with that of 2009. The average value for U.S. ground silicon carbide exports was $5,970 per ton, a 95% increase compared with that of 2009.

Crude silicon carbide imports from China had an average value of $801 per ton. The average value of crude silicon carbide imports from other countries was $778 per ton. Silicon carbide grain imports from China had an average customs value of $1,260 per ton. The average customs value of silicon carbide grain imports from other countries was $2,520 per ton (table 6).

Global prices for silicon carbide steadily increased throughout 2008 despite poor global economic conditions (Kennedy, 2008); then during 2009, the poor global economic conditions caused average prices to drop each quarter of that year. This trend reversed during 2010, as silicon carbide prices steadily increased throughout the year, reflecting improvement in global economic conditions. This price trend was demonstrated by the quarterly average unit values for imports of both types of silicon carbide. Crude silicon carbide import unit values increased from $544 per ton in the first quarter to $1,010 per ton in the fourth quarter, and silicon carbide grain unit values increased from $2,110 per ton in the first quarter to $2,200 per ton in the fourth quarter of 2010.

Foreign Trade.—In 2010, the United States exported crude silicon carbide to 23 countries and refined and ground silicon carbide to 39 countries. The total crude silicon carbide exports for 2010 increased by 7% compared with those of the previous year to 18,200 t valued at $26.6 million (table 5). Of the exported crude silicon carbide material, 71% was shipped to Norway. Compared with those of 2009, exports of refined or ground silicon carbide increased by 31% to 4,920 t valued at $29.4 million. Of the exported refined and ground material, 37% was shipped to Canada.

In 2010, the United States imported crude silicon carbide from 15 countries and imported ground and refined silicon carbide from 19 countries. Imports of crude silicon carbide increased by 66% during the year to 99,300 t valued at $78.7 million (table 6). Imports of silicon carbide in ground or refined form increased by 140% to 43,400 t valued at $85.9 million. China accounted for 65% of the crude silicon carbide imports and 43% of the ground and refined silicon carbide imports. A large part of the imports from China reportedly included metallurgical-grade material. During 2010, China doubled its silicon carbide production and was the world's leading producer of silicon carbide. With all grades and end uses of silicon carbide added together, China held a 70% global market share during 2010 (O'Driscoll and Watts, 2011).

These relatively large increases in the quantities and values of silicon carbide exports and imports were owing to the improvement of global economic conditions during 2010 and its impact on industries that use silicon carbide.

Aluminum-Zirconium Oxide

During 2010, fused aluminum-zirconium oxide for abrasive applications, such as resin-bonded grinding wheels, was produced at one plant in the United States, belonging to Saint-Gobain Abrasives, and one plant in Canada, belonging to Saint-Gobain Ceramic Materials Canada Inc., but production data from these plants are withheld to avoid disclosing company proprietary information.

Boron Carbide

Washington Mills Electro Minerals was the only commercial producer of boron carbide in the United States during 2010. Boron carbide was used as an abrasive for lapping and ultrasonic cutting operations previously possible only with diamond dust; it was also molded to form highly wear-resistant products, such as armor, powdered metal and ceramic forming dies, pressure blasting nozzles, thread guides, and wire-drawing dies. Boron carbide was also used in nuclear applications, such as neutron-absorbing shielding and reactor control rods (Washington Mills Electro Minerals Corp., 2008). Domestic production data for boron carbide are withheld to avoid disclosing company proprietary data.

Metallic Abrasives

Production.—Data on U.S. production and shipments of metallic abrasives were based on a survey of domestic producers conducted by the USGS. Survey data were collected from 11 companies operating 12 plants in the United States and accounted for all domestic production (table 3).

Steel shot and grit accounted for almost all the metallic abrasives produced domestically (table 4). U.S. production of steel shot and grit in 2010 increased by 21% compared with that of 2009. Six companies reported production of cut wire shot in 2010, and most of that was cut from carbon steel wire and stainless steel wire. Other products reported included shot cut from aluminum, copper, and zinc wire. One company reported production of steel nuggets, a wrought carbon steel blast medium with properties similar to those of steel shot.

Consumption.—Metal abrasives are used primarily as loose particles propelled at high velocities for blast cleaning or to improve the properties of metal surfaces; 75% of the abrasives is employed in cleaning operations. Principal consumers include foundries, machine tool industries, metalworking plants (particularly those supporting the automotive and aircraft industries), and steel manufacturers.

During 2010, total sales of all steel shot and grit by U.S. producers increased by 23% to 185,000 t, compared with shipments in 2009.

Prices.—The USGS compiles survey data on the value of production and shipments, but it does not collect price data. The values of production and shipments reported by metallic abrasive producers in 2010 are listed in table 4. Average unit values of steel shot and grit ranged from $0.33 to $1.23 per kilogram. Average unit values of cut wire shot ranged from $1.90 to $6.30 per kilogram for carbon steel, stainless steel, and zinc wire shot. The average unit value for total U.S. production of steel shot and grit in 2010 was $0.49 per kilogram, and the average unit value for total sales of all steel shot and grit by U.S. producers was $0.59 per kilogram. Average unit values for metallic abrasives traded by the United States during 2010 were $1.34 per kilogram for exports and $0.58 per kilogram for imports.

Foreign Trade.—During 2010, the United States exported metallic abrasives to 37 countries and imported metallic abrasives from 16 countries. U.S. exports of metallic abrasives increased by 19% during the year to 30,800 t valued at $41.3 million (table 5). Canada, China, and Mexico received 90% of the U.S. exports of metallic abrasives in 2010. U.S. imports increased by 175% during 2010 to 43,400 t valued at $25.3 million (table 6). About 87% of the imports came from Canada, Germany, and Sweden.

These relatively large increases in the quantities and values of metallic abrasives exports and imports are owing to the improvement of global economic conditions during 2010 and its impact on industries that use metallic abrasives.

Outlook

Abrasives markets are greatly influenced by activity in the manufacturing sector in the United States and by economic trends. During 2010, increases in the U.S. manufacturing sector resulted from improvement in the global economy that caused increases in U.S. manufactured abrasives production and consumption. This was particularly true of manufacturing activities in the aerospace, automotive, furniture, housing, and steel industries. Even though abrasives markets are linked to these end-use manufacturing sectors, growth in these sectors may not necessarily lead to an increase in abrasives consumption.

The U.S. abrasive markets also are influenced by technological trends. Improved technology in these manufacturing sectors has resulted in surface quality that requires fewer grinding and finishing operations that use abrasives (O'Driscoll, 2003). Less expensive imports coupled with higher domestic production costs and low domestic production capacity continue to challenge U.S. producers of fused aluminum oxide and silicon carbide to maintain market share. Competition from developing nations, especially China, probably will lead to further decreases in domestic output. China has become a dominant force in both fused aluminum oxide and silicon carbide production in recent years. This has changed the makeup of the manufactured abrasives market. Lower-priced Chinese exports have displaced and are expected to continue to displace manufactured abrasives produced in Europe and North America (Gasser, 2002). The traditional suppliers among the Western industrialized nations are expected to continue consolidating and contracting.

Emerging suppliers of fused aluminum oxide and silicon carbide in China, Eastern Europe, India, the Republic of Korea, and South America are likely to continue to increase their prominence in world markets. China is now the world's leading producer of silicon carbide and is expected to continue expanding silicon carbide output to meet increases in global market demand (O'Driscoll and Watts, 2011). Further success for these suppliers, particularly in such major markets as Japan, the United States, and Western Europe, will depend on their ability to provide higher grades of material and levels of supply reliability while maintaining lower prices. Energy costs, furnace size, quality-control systems, and the availability of essential mineral inputs are expected to be the dominant factors influencing the competitive stance of these suppliers.

The aerospace and automotive manufacturing sectors are likely to continue to have significant indirect influences on demand for manufactured abrasives used by metalworking operations supporting those sectors. The housing construction sector in North America is expected to continue to have an indirect influence on demand for manufactured abrasives because of the large volumes of manufactured abrasives used in cutting and finishing wallboard and timber.

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GENERAL SOURCES OF INFORMATION

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TABLE 1

CRUDE ARTIFICIAL ABRASIVES MANUFACTURERS IN 2010

Company	Plant location	Product
Saint-Gobain Ceramic Materials Canada Inc.	Chippewa, Ontario, Canada	Aluminum-zirconium oxide.
Saint-Gobain Abrasives	Huntsville, AL	Fused aluminum oxide (high-purity) and aluminum-zirconium oxide.
Washington Mills Electro Minerals Corp.	Niagara Falls, NY	Fused aluminum oxide (high-purity) and boron carbide.
Do.	Niagara Falls, Ontario, Canada	Fused aluminum oxide (regular).
Washington Mills Hennepin, Inc.	Hennepin, IL	Silicon carbide.

Do. Ditto.

TABLE 2

ESTIMATED PRODUCTION OF CRUDE SILICON CARBIDE AND FUSED ALUMINUM OXIDE IN THE UNITED STATES AND CANADA[1, 2]

	2009		2010	
Product	Quantity[3, 4] (metric tons)	Value[3] (thousands)	Quantity[3, 4] (metric tons)	Value[3] (thousands)
Aluminum oxide, regular, abrasives[5]	10,000	$1,700	10,000	$1,700
Silicon carbide[6]	35,000	25,900	35,000	25,900

[1] Data are rounded to no more than three significant digits.

[2] Yearend stock data are withheld to avoid disclosing company proprietary data.

[3] Owing to rounding, data do not match total quarterly Mineral Industry Surveys estimated data.

[4] Quantities are rounded to the nearest 5,000 metric tons to avoid disclosing company proprietary data.

[5] Regular grade accounts for about 62% of total output, and high-purity material accounts for the remainder.

[6] Approximately one-half of the quantity and value consists of material for metallurgical and other nonabrasive applications.

TABLE 3
U.S. PRODUCERS OF METALLIC ABRASIVES IN 2010

Company	Plant location	Product [shot and (or) grit]
Abrasive Materials, LLC	Hillsdale, MI	Cut wire.
Chesapeake Specialty Products, Inc.	Baltimore, MD	Steel.
Ervin Industries, Inc.	Adrian, MI	Do.
Do.	Butler, PA	Do.
Frohn North America, Inc.	Austell, GA	Cut wire.
MLP Steel, LLC	Scottdale, PA	Do.
Metaltec Steel Abrasive Co.	Canton, MI	Steel.
Peerless Metal Powders & Abrasive Co., Inc.	Detroit, MI	Steel and steel nuggets.
Pellets, LLC	Tonawanda, NY	Cut wire.
Platt Brothers & Co., Inc., The	Waterbury, CT	Do.
Premier Shot Co.	Cleveland, OH	Do.
Wheelabrator Abrasives Inc.	Bedford, VA	Steel.

Do. Ditto.

TABLE 4
PRODUCTION AND SHIPMENTS FOR METALLIC ABRASIVES IN THE UNITED STATES, BY PRODUCT[1]

	Production		Shipments[2]	
Product	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009:				
Steel shot and grit	137,000	$64,900	151,000	$83,700
Cut wire shot and other[e]	1,470	5,390	1,490	5,800
Total	138,000	70,300	152,000	89,500
2010:				
Steel shot and grit	166,000	81,300	185,000	109,000
Cut wire shot and other[e]	2,120	7,770	1,990	8,420
Total	169,000	89,100	187,000	117,000

[e] Estimated.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes reported exports.

TABLE 5

U.S. EXPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC ABRASIVES, BY COUNTRY AND TYPE[1]

	2009		2010	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Aluminum oxide, crude:				
Brazil	141	$650	314	$1,480
Canada	5,470	7,210	7,280	11,200
China	143	959	211	2,380
Germany	1,680	6,020	3,690	15,300
India	189	878	342	1,840
Japan	724	4,450	1,030	12,400
Korea, Republic of	430	3,180	1,090	9,000
Mexico	2,060	3,430	2,910	4,630
United Kingdom	634	1,640	1,730	2,250
Other	854	3,620	1,370	7,350
Total	12,300	32,000	20,000	67,900
Silicon carbide:				
Crude:				
Germany	2,550	3,020	3,040	3,470
Japan	32	458	64	1,500
Mexico	759	1,310	1,440	2,250
Norway	13,400	19,500	13,000	17,800
Other	182	1,890	669	1,650
Total	16,900	26,200	18,200	26,600
Ground and refined:				
Canada	1,680	2,540	1,810	2,620
China	71	475	261	2,530
Germany	349	4,440	495	14,700
Japan	270	873	822	3,200
Mexico	996	1,570	1,070	1,670
Other	380 [r]	1,600 [r]	473	4,700
Total	3,750	11,500	4,920	29,400
Metallic abrasives:				
Canada	5,160	4,730	6,580	6,520
China	7,470	10,400	8,340	12,600
Germany	172	572	230	956
Indonesia	824	1,500	48	28
Japan	963	972	508	487
Mexico	8,750	9,390	12,900	16,000
Taiwan	458	447	273	483
United Kingdom	753	2,080	488	656
Other	1,370	2,170	1,390	3,530
Total	25,900	32,200	30,800	41,300

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

TABLE 6
U.S. IMPORTS OF ALUMINUM OXIDE, SILICON CARBIDE, AND METALLIC ABRASIVES, BY COUNTRY AND TYPE[1]

	2009		2010	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Aluminum oxide:				
Crude:				
Canada	8,450	$6,530	7,180	$4,780
China	24,200	12,900	108,000	59,700
Venezuela	5,090	3,610	20,400	11,400
Other	489	181	4,580	2,250
Total	38,200	23,200	141,000	78,100
Ground and refined:				
Austria	4,210	7,100	8,010	14,400
Brazil	9,240	7,280	14,200	14,200
China	3,710	2,920	4,230	3,710
Germany	5,020	7,390	10,100	14,100
Hungary	1,100	1,090	2,530	2,430
Italy	982	1,210	1,720	2,160
Other	1,760 [r]	3,500 [r]	3,810	7,080
Total	26,000	30,500	44,600	58,000
Silicon carbide:				
Crude:				
China	39,700	24,000	64,800	51,900
Netherlands	4,540	1,330	3,020	1,340
Romania	4,320	1,260	9,240	4,400
South Africa	5,920	3,570	10,500	10,900
Venezuela	4,500	2,000	6,240	3,460
Other	935 [r]	1,250 [r]	5,510	6,710
Total	59,900	33,400	99,300	78,700
Ground and refined:				
Brazil	4,000	5,760	9,260	13,400
China	6,660	9,200	18,600	23,500
Germany	1,570	6,800	2,570	7,620
Japan	1,070	7,330	1,910	15,500
Norway	1,660	8,120	3,170	15,500
Russia	1,280	1,410	3,030	3,410
Vietnam	1,120	1,080	1,280	1,250
Other	725	1,430	3,520	5,730
Total	18,100	41,100	43,400	85,900
Metallic abrasives:				
Canada	6,380	3,920	9,610	6,990
China	1,690	3,680	1,550	2,810
Germany	1,300	1,040	1,810	1,510
Sweden	3,400	1,100	26,500	10,200
Other	3,040	2,330	4,000	3,750
Total	15,800	12,100	43,400	25,300

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

ALUMINUM

By E. Lee Bray

Domestic survey data and tables were prepared by Glenn J. Wallace, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

During 2010, domestic primary smelters produced 1.73 million metric tons (Mt) of aluminum metal, the same as in 2009, valued at $3.98 billion, 31% more than the value of the production in 2009. At yearend, five companies were operating nine primary aluminum smelters in seven States. Smelters east of the Mississippi River accounted for about 71% of the production. An additional five smelters were temporarily idle. Two other smelters that had been temporarily idle were permanently closed. About 56% [1.78 million metric tons per year (Mt/yr)] of domestic primary aluminum smelting capacity (table 2), including idle potlines at operating smelters, was not being used.

Aluminum recovered from purchased scrap was essentially unchanged at 2.8 Mt. Of this recovered metal, 55% came from new (manufacturing) scrap, and 45% came from old (discarded aluminum products) scrap. Aluminum used beverage cans (UBCs) accounted for 48% of the reported old scrap consumed in 2010 and 21% of total scrap consumed.

Apparent consumption of aluminum increased by 4% compared with that in 2009. The United States and Canadian transportation industry accounted for 28.6% of metal shipments by United States and Canadian producers; containers and packaging, 22.4%; building and construction, 10.2%; electrical, 7.1%; machinery and equipment, 7.1%; consumer durables, 6.1%; and other uses, 3.1%. Exports accounted for 15.4% of shipments from producers in Canada and the United States in 2010 (table 6).

The 2010 annual average U.S. market price of primary aluminum ingot increased by 31% to $1.044 per pound from $0.794 per pound in 2009. The monthly average price fluctuated between $0.934 per pound and $1.109 per pound during the first 9 months of 2010, before stabilizing at about $1.12 per pound during the fourth quarter of the year.

At yearend 2010, total (unwrought, scrap, in process metal, and semifabricated) world inventories of aluminum, as reported by the International Aluminium Institute (IAI) (2011), were 13% higher than those at yearend 2009. Combined inventories of aluminum metal and alloys held by the London Metal Exchange Ltd. (LME) (2009; 2010), however, decreased by 8%.

Primary aluminum was produced in 42 countries in 2010. China, Russia, Canada, and Australia, in decreasing order of metal produced, accounted for 61% of total world production. World primary metal production increased by 11% compared with that of 2009 owing to increased production in China (3.3 Mt), the United Arab Emirates [390,000 metric tons (t)], Qatar (180,000 t), Russia (132,000 t), Germany (102,000 t), Kazakhstan (100,000 t), New Zealand (73,000 t), and several other nations. Commissioning of new smelters and brownfield expansions, as well as restarted capacity closed during the financial crisis, accounted for the increased production. These increases were partially offset by decreased production of 330,000 t in Norway, 75,000 t in Venezuela, 67,000 t in Canada, and 67,000 t in the United Kingdom, as older smelters were closed, and droughts limited hydroelectric power in some locations. The United States remained the 5th leading producer of primary aluminum.

Production

Primary.—In June, Alcoa Inc. (Pittsburgh, PA) and workers represented by the United Steelworkers (USW) union ratified a 4-year contract that addressed issues such as health care, pay increases, and workplace flexibility. The contract covered 5,400 hourly workers at 10 locations in the United States, including 6 primary smelters at Alcoa, TN; Massena, NY (2); Rockdale, TX; Wenatchee, WA; and Warrick, IN. The previous 4-year contract had expired May 31, and work had continued without interruption at all locations during the negotiations (Alcoa Inc., 2010b).

In April, Alcoa announced that the temporary closures of the Badin, NC, and Frederick, MD, smelters would be made permanent, and the sites would be remediated. The Badin smelter was first opened in 1916 and last operated in August 2002. It had a capacity of 120,000 metric tons per year (t/yr) of aluminum. The Frederick smelter, which began production in 1970, had a capacity of 195,000 t/yr when it closed in December 2005. High power prices were cited as reasons for initial closure of both smelters, and subsequent efforts to obtain long-term power contracts at competitive prices were unsuccessful (Alcoa Inc., 2010c).

A 5-year labor contract between Century Aluminum Co. (Monterey, CA) and more than 540 hourly employees represented by the USW at the 244,000-t/yr smelter in Hawesville, KY, was ratified on December 23 (Century Aluminum Co., 2010c). Production had continued since the previous contract expired on March 31. Prior to the contract ratification, Century announced that it would restart a potline that was closed in March 2009 when prices and demand for aluminum had declined. The restart was to be completed by the end of March 2011 and would restore full production at the smelter (Century Aluminum Co., 2010a).

Ormet Corp. restarted two potlines at its 265,000-t/yr smelter in Hannibal, OH, at the end of November. The restart of the potlines was expected to be completed in the first quarter of 2011 and bring production at the smelter to full capacity (Ormet Corp., 2010). One of the potlines was shut down in May 2009, and the other was shut down in August as a result of a disputed alumina supply agreement with its previous supplier, Glencore International AG.

Noranda Aluminum Holding Corp. (Franklin, TN) returned the New Madrid, MO, smelter to full capacity in March after it shut down during a power failure caused by a storm in January

2009. About 75% of the smelter's capacity was shut down, and restart of the potlines began in early 2009 and continued through the first quarter of 2010 (Noranda Aluminum Holding Corp., 2010b).

A project to expand the New Madrid smelter capacity to 266,000 t/yr from 250,000 t/yr resumed in September. The project, which had initially started in mid-2008 but was put on hold in early 2009 during the financial crisis, was expected to be completed by the beginning of 2013 (Noranda Aluminum Holding Corp., 2010a).

Secondary.—In March, Alcoa completed a 50% expansion of its UBC recycling facility in Alcoa, TN. The project, which included a new crusher, delacquering furnace, and emissions control systems, was part of Alcoa's efforts to increase recycling of UBCs in the United States (Alcoa Inc., 2010a). Work on the project started in December 2007 and had been originally planned for completion in 2009, but construction was slowed during the global financial crisis.

In September, a fire at Alcoa's Knoxville, TN, plant forced a several-week shutdown of its rolling mill. The rolling mill had a capacity of 500,000 t/yr and produced mostly can sheet. Other parts of the plant were not affected and continued production (American Metal Market, 2010b).

In July, Aleris International Inc. restarted production at its Coldwater South secondary smelter in Coldwater, MI. The smelter had a capacity of approximately 130,000 t/yr of alloys commonly used for manufacturing automotive parts. The smelter had shut down in May 2009 owing to a cutback in automobile manufacturing (Platts Metals Week, 2010c).

Bermco Aluminum Co. (Birmingham, AL) announced plans to relocate its secondary smelter from Birmingham, AL, to Lincoln, AL. The new smelter would have a capacity of 110,000 t/yr compared with the current location's capacity of 55,000 t/yr. The smelter produced diecast and foundry alloys used by automobile parts manufacturers and other consumers. Construction was planned to start in mid-2011, and full production was expected by mid-2012 (Platts Metals Week, 2010e).

Logan Aluminum Inc. (a joint venture between Arco Aluminum Inc. and Novelis Inc.) installed support equipment for a furnace at its UBC recycling facility and rolling mill in Russelville, KY. Briquetters to compress shredded UBCs were installed to increase the operational efficiency of the furnace that was started up in 2008, which produced approximately 65,000 t/yr of metal from UBCs and other scrap without generating salt cake (Light Metal Age, 2010).

Sapa Extrusions Ltd. planned to build a billet casting facility at its Cressona, PA, extrusion plant by September 2011. The casting pit would have a capacity of 545,000 t/yr of billet, produced mainly from scrap. Increasing demand for extruded aluminum products and tight supplies of extrusion billet were cited as reasons for the expansion (Platts Metals Week, 2010g).

Skana Aluminum Co. (Manitowoc, WI) reopened a rolling mill with two rebuilt furnaces in July. The plant, formerly owned by Koenig and Vits Inc., shut down in May 2009 amid financial troubles leading to an asset sale in bankruptcy. At capacity, the plant was expected to produce 30,000 t/yr of sheet for cookware and automotive parts manufactured from scrap (Mason, 2010).

Spectro Alloys Corp. (Rochester, MN) replaced a damaged 65,000-t/yr furnace that was taken out of service early in the year. The new furnace had a capacity of approximately 52,000 t/yr and was put into operation in July. The secondary smelter produced alloys used by the automobile industry and other consumers (American Metal Market, 2010c).

Consumption

Apparent consumption of aluminum in the United States increased by 4% in 2010 compared with that in 2009. Shipments of aluminum by United States and Canadian producers to their combined domestic markets increased by 22% in 2010 compared with the amount shipped in 2009. Shipments of aluminum for containers and packaging in 2010 increased slightly compared with those in 2009. Shipments to the transportation sector increased by 46%, building and construction by 4%, consumer durables by 31%, electrical by 18%, and the machinery sector by 47%.

The increase in shipments of aluminum to the transportation sector resulted primarily from an expansion of automobile production. Manufacturing of light vehicles in North America increased by 39% in 2010 compared with production in 2009, and in the United States, increased by 35% to 7.58 million units from 5.61 million units. Production in the first half of 2009 had been significantly reduced by extended shutdowns as a result of the bankruptcies of General Motors Co. and Chrysler Group LLC (CSM Worldwide Inc., 2010; IHS Automotive Inc., 2011).

The Boeing Co. (Chicago, IL) reported that its deliveries of commercial aircraft were 4% lower than in 2009 owing to a decline in deliveries of wide-body models. Deliveries of the single-aisle 737 aircraft increased slightly as airlines continued to replace older aircraft with more fuel efficient models (Boeing Co., The, 2011, p. 24).

The decrease in aluminum shipments for use in building and construction was a result of reduced nonresidential and residential construction. The U.S. Census Bureau and the U.S. Department of Housing and Urban Development jointly reported that housing starts were up by 6.1% in 2010 compared with starts in 2009. The number of houses completed, however, was 17.7% fewer than in 2009 (U.S. Census Bureau, 2011b). Spending on nonresidential construction during 2010 decreased by 13.9% compared with that in 2009. Total construction spending during 2010 was down 10.3% compared with that in 2009 (U.S. Census Bureau, 2011a).

Stocks

According to data reported by the Aluminum Association Inc. (2011), United States and Canadian producers' combined inventories of aluminum ingot, mill products, and scrap increased by 8% to 1.01 Mt at yearend 2010 from 937,000 t at yearend 2009. The LME reported that primary aluminum metal ingot stocks at its U.S. warehouses increased by 3% to 2.09 Mt at yearend 2010 from 2.02 Mt at yearend 2009. At yearend 2010, LME warehouses in the United States also held about 70,000 t of North American special aluminum alloy contract (NASAAC) metal ingot, a 61% decrease from the 180,000 t held at yearend 2009 (London Metal Exchange Ltd., 2009, 2010).

Prices

The monthly average U.S. market price of primary aluminum metal, as reported by Platts Metals Week, started the year at $1.069 per pound of aluminum and fluctuated between $0.934 per pound and $1.109 per pound until October. The monthly average price was about $1.12 per pound in each of the past 3 months of the year. The annual average price in 2010 increased to $1.044 per pound from $0.794 per pound in 2009. The LME monthly average cash prices for primary aluminum ingot followed the same general trend as the U.S. market price, and the 2010 annual average LME cash price increased to $0.986 per pound from $0.755 per pound in 2009. The indicator prices for selected secondary aluminum ingots and scrap, as published in American Metal Market, followed the same trend as primary ingot prices (table 8).

Foreign Trade

In 2010, total net imports of aluminum-base materials decreased by 20% compared with net imports in 2009 (tables 9 and 11). Imports for consumption of crude aluminum decreased by 9%, while imports of semifabricated aluminum materials (plates, sheet, and bars) increased by 23%, and scrap imports increased by 16% compared with those of 2009. Canada remained the leading source country, accounting for 63% of the total (crude, semifabricated, and scrap) imports in 2010, while China (7%) and Russia (5%) were the second and third ranked suppliers (table 12).

Exports of crude aluminum (metal and alloys) increased by 8% and exports of semifabricated aluminum materials increased by 7% compared with those of 2009. Net exports of 1.41 Mt of scrap increased by 15% compared with the amount in 2009. About 79% of total U.S. exports of unmanufactured aluminum (crude, semifabricated, and scrap) in 2010 was collectively shipped to China, Canada, and Mexico. The aluminum shipped to China was 97% scrap (table 10).

Mergers and Acquisitions

Norsk Hydro ASA (Oslo, Norway) and Vale SA (Rio de Janeiro, Brazil) announced a deal in May in which Norsk Hydro would purchase Vale's bauxite, alumina, and aluminum assets in Brazil in exchange for $1.1 billion in cash plus $3.8 billion in stock of Norsk Hydro. As a result of the transaction, Vale would own 22% of Norsk Hydro; Norsk Hydro would own 51% of the 460,000-t/yr Albras smelter; and Norsk Hydro would increase its share of the 6.3-Mt/yr Alunorte refinery to 91% from 34% and of the 1.86-Mt/yr Companhia de Alumina do Para refinery project to 81% from 20%. Norsk Hydro would also gain ownership of 60% of the Paragominas bauxite mine (9.9 Mt/yr capacity) with an option to purchase the remaining 40% of the mine by yearend 2015 (Norsk Hydro ASA, 2010d; Platts Metals Week, 2010f). The companies had planned to complete the transaction by yearend but closing was delayed until early in 2011 awaiting regulatory approval (Norsk Hydro ASA, 2010g). In a separate transaction, Norsk Hydro acquired full control of a secondary smelter in Taiwan when it acquired Formosa Alloy Materials Co.'s 15.1% share. The 75,000-t/yr smelter produced extrusion billet sold mostly in Asia, but also exported billet to Norsk Hydro customers in the United States (Norsk Hydro ASA, 2010c). Aleris emerged from chapter 11 bankruptcy on June 1. The secondary smelter and rolling mill company had filed for bankruptcy protection February 12, 2009, citing financial pressures and declining demand and prices for its products amid the global financial crisis. A consortium of creditors, led by private equity firms Apollo Management, L.P., Oaktree Capital Management, L.P., and Sankaty Advisors, LLC, took ownership of the company (Aleris International Inc., 2010). The company continued to operate during the bankruptcy proceedings under terms of a debtor-in-possession financing agreement approved in 2009.

World Industry Structure

Production.—World primary aluminum production increased by 11% in 2010 compared with that of 2009 owing to smelter reopenings and expansions as prices recovered from the lows during the financial crisis. China was the leading producer and accounted for 40% of global production. China, Russia, Canada, and Australia, in decreasing order of production, accounted for 61% of total world primary aluminum production.

During the fourth quarter of 2008 and early 2009, many primary smelters announced shutdowns in response to declining prices, as demand for aluminum receded in the face of the financial crisis. Throughout 2010, most of these shutdowns were continued, although several restarts were announced in the second half of the year.

Stocks.—As aluminum demand increased and prices recovered from the lows during the financial crisis in 2009, aluminum inventories stabilized during the fourth quarter of 2010. Unwrought aluminum inventories held by member producers of the IAI increased by 16% to 1.40 Mt at yearend 2010 from 1.21 Mt at yearend 2009. Unwrought aluminum is defined by the IAI as aluminum in its basic form made from primary metal or from scrap and that is metallurgically unworked. Total IAI aluminum inventories increased by 13% to 2.52 Mt at yearend 2010 from 2.23 Mt at yearend 2009. Total aluminum includes unwrought aluminum plus unprocessed scrap, metal in process, and finished semifabricated (mill) products (International Aluminium Institute, 2011).

Yearend 2010 inventories of primary aluminum metal held by the LME decreased by 8% to 4.27 Mt from 4.62 Mt at yearend 2009, aluminum alloy inventories decreased by 17% to 70,000 t from 84,500 t, and NASAAC ingot inventories decreased by 26% to 134,000 t from 180,000 t (London Metal Exchange Ltd., 2009, 2010).

Primary aluminum metal ingot stocks at U.S. LME warehouses increased by 3% to 2.09 Mt at yearend 2010 from 2.02 Mt at yearend 2009. At yearend 2010, LME warehouses in the United States also held about 134,000 t of NASAAC metal ingot, a 26% decrease from the 180,000 t held at yearend 2009 (London Metal Exchange Ltd., 2009, 2010).

World Review

Argentina.—Aluminio Argentino S.A.I.C. (Aluar) started production in July from 24 new pots that were part of an expansion of its smelter. A total of 72 new pots were included in the expansion and would bring smelting capacity to 425,000 t/yr from 410,000 t/yr by 2011 (Platts Metals Week, 2010d).

Australia.—The Australian Government announced it was deferring implementation of a cap-and-trade program aimed at reducing greenhouse gas emissions. The proposal was withdrawn in April because of a lack of agreement in Parliament (Australian Department of Climate Change, 2010). The proposal would have included provisions for the aluminum industry and other emission-intensive industries to mitigate the costs during the first several years of implementation.

A power supply contract was reached in November between Tomago Aluminium Co. Pty. Ltd. and Macquarie Generation Pty. Ltd. The new contract would start when the current contract expires in 2017 and last until 2028. The Tomago smelter was a joint venture between Rio Tinto (52%), Gove Aluminium Finance Ltd. (36%), and Norsk Hydro (12%) and had a capacity of 528,000 t/yr. The smelter operator was discussing opportunities to sell molten aluminum to manufacturers considering building facilities near the smelter (Norsk Hydro ASA, 2010j).

Alcoa of Australia Ltd. and Loy Yang Power Ltd. signed long-term power contracts for the Point Henry and Portland smelters. A total of 820 megawatts (MW) would be provided to the two smelters through 2036. The contract for the Point Henry smelter would start in 2014 and the contract for the Portland smelter would start in 2016, when the current contracts expire. The Point Henry smelter had a capacity of 190,000 t/yr, and the capacity of the Portland smelter was 358,000 t/yr. The contracts provided for increased power supplies in the event of expansion of the smelters (Alcoa Inc., 2010f).

Bahrain.—Aluminum Bahrain Ltd. (Alba) was planning to expand production capacity by adding more pots to two of its five potlines and optimizing the power efficiency of those potlines. The project would increase capacity of the smelter to 970,000 t/yr from 870,000 t/yr. The project would be completed by yearend 2012, although specific plans were not released. Alba also was planning an additional potline for completion by yearend 2014. The capacity of the proposed new potline would be 400,000 t/yr and would bring total capacity of the smelter to 1.37 Mt/yr when completed (Platts Metals Week, 2010a).

Bosnia and Herzegovina.—Aluminij d.d. Mostar restarted approximately 35,000 t/yr of capacity at its 135,000-t/yr smelter during the first quarter. The smelter had shut down the capacity in early 2009 in response to falling demand and prices for aluminum (CRU Aluminium Monitor, 2010b).

Brazil.—Novelis Inc. (a subsidiary of Hindalco Industries Ltd.) closed its 60,000-t/yr primary smelter at Aratu at yearend. Novelis cited low prices, high operating costs from logistical issues with the smelter's location, high-priced power, outdated technology, and its small size as reasons for closing (Novelis Inc., 2010).

Brazil recycled 98.2% of all aluminum beverage cans sold in the country during 2009. Brazil collected and recycled 198,800 t of UBCs, the equivalent of 14.7 billion aluminum cans. For the ninth consecutive year, Brazil had the highest aluminum can recycling rate among countries that do not have mandatory recycling laws. Sales of aluminum beverage cans increased by 12% during 2010 compared with the number sold during 2009, and the volume of UBCs collected increased by 19.9% compared with that of 2009 (Associação Brasileira do Alumínio, 2010).

Canada.—One-half of the 235,000-t/yr smelter in Laterriere, Quebec, was shut down from July through September after the failure of two electrical transformers in July (Rio Tinto plc, 2010a).

Rio Tinto was moving forward with construction of a new smelter in Saguenay, Quebec, although progress had been slowed during the financial crisis. The first phase of smelter operation would be in early 2013, with a capacity of 60,000 t/yr. Additional potlines were planned that would bring total capacity of the smelter to 460,000 t/yr, although a project schedule was not available (Rio Tinto plc, 2010b).

The Kitimat smelter modernization project that was delayed during the financial crisis was also progressing. When completed, the capacity of the Kitimat smelter would increase to 420,000 t/yr from 277,000 t/yr. New prebaked pots would replace the Soderberg pots to increase efficiency and reduce emissions (Rio Tinto plc, 2010b). In preparation for expansion of the smelter, two potlines with a combined capacity of 67,000 t/yr were permanently shut down, and demolition begun in August (Riley, 2010b; Rio Tinto plc, 2010c, p. 7, 15).

China.—Primary aluminum production in China increased by 26% compared with that in 2009. Capacity expansions and restarts of temporary closures outweighed closures of inefficient smelters and from reduced output during power reductions at others (table 13).

The Government ordered that preferential power rates be discontinued to energy-intensive sectors including primary aluminum smelters in several provinces by mid-June. The Government also ordered highly polluting or inefficient smelters to be shut down. The policy was aimed at reducing energy consumption and pollution in fast growing provinces of China. Other industries affected by the order included ferroalloys, magnesium, silicon, and titanium (Wong, 2010).

The Ministry of Industry and Information Technology announced that obsolete potlines, having a combined capacity of 422,000 t/yr, at 15 smelters would be permanently closed by the end of September. In Shanxi Province the affected smelters were Shanxi Zhenxing Aluminum Co. Ltd. (20,000 t/yr), Taiyuan East Aluminum Co. Ltd. (15,000 t/yr), Hanzhou Zinc Industrial Special Material Co. Ltd. (7,210 t/yr), and Shanxi Jinxin Aluminum Co. Ltd. (7,000 t/yr). In Shandong Province, affected smelters were Shandong Aluminum Co. Ltd. (20,000 t/yr) and Zibo Aluminum Co. Ltd. (10,000 t/yr). In Henan Province, the policy applied to Chinalco Henan Branch (60,000 t/yr), Sanmenxia Tianyuan Aluminum Co. Ltd. (30,000 t/yr), Qin'ao Aluminum Co. Ltd. (20,000 t/yr), and Western Aluminum Co. Ltd. (2,500 t/yr). In Hunan Province, 60,000 t/yr of capacity at the Hunan Maoerkou Aluminum Smelter Co. Ltd. was closed. Affected smelters in Guizhou Province were the Shuangpai Aluminum Co. Ltd. (50,000 t/yr) and the Guiyang Jinyuan Aluminum Co. Ltd. (30,000 t/yr). Chinalco's Liancheng branch closed 40,000 t/yr of capacity in Gansu Province. In Qinghai Province, Qinghai Products and Industry Investment Co. Ltd. closed 50,000 t/yr of capacity. The pots closed had amperages of 100 kiloamps (KA) or less, considered to be less efficient than newer potline designs that have amperages of 300 KA or greater. The potlines included Soderberg and prebaked pot designs, and many of the potlines were shutdown prior to the policy being announced (China Metal Market—Alumina & Aluminum, 2010b).

In September, the government of Guangxi Zhuang Autonomous Region announced strict regulations on expansion of energy- and emissions-intensive industries, including primary aluminum smelting. Other industries included were copper, lead, iron and steel, and zinc. Power supplies to these industries were also cut at the beginning of September, resulting in some production cuts. New smelters would not be approved for at least 1 year (China Metal Market—Alumina & Aluminum, 2010h, i). The provincial government of Inner Mongolia also announced similar policies, including the closure of 800,000 t/yr of capacity at smelters with outdated or inefficient technology. A moratorium on new smelter construction until 2011 was part of the policy (CRU Aluminium Monitor, 2010b). Hebei, Jiangsu, Shandong, Shanxi, and Zhejiang Provinces were also implementing power restrictions to aluminum smelters and other power intensive industries starting in July (China Metal Market—Alumina & Aluminum, 2010l).

In order to decrease energy consumption, the Henan Provincial government ordered smelters to shut down outdated and inefficient capacity. A total of 720,000 t/yr of capacity was affected by the ordered shutdown. All pots using less than 160 kilo amps (KA) were to be shut down. Thirty percent of the pots in the Province with amperage of 180 to 300 KA were to be shut down on a rotational basis. Other industries including calcium carbide, caustic soda, ferroalloys, iron and steel, and polycrystalline silicon were also affected by the policy to reduce power consumption (China Metal Market—Alumina & Aluminum, 2010k). In Qinghai Province, the continuation of a similar policy shut down 50,000 t/yr of obsolete potlines during the year. Since 2006, 165,000 t/yr of capacity had been shut down because of the policy. Other potlines were being evaluated to determine if they would be forced to shut down (China Metal Market—Alumina & Aluminum, 2010n). Zunyi, Guizhou Province, cut power supplies by one-half to three smelters in the city at the end of August because of power shortages and to decrease pollution. The smelters were owned by Zunyi Aluminum Co. Ltd., Zunyi Yulong Aluminum Co. Ltd., and Zunyi Weiming Aluminum Co. Ltd., which had a combined capacity of 420,000 t/yr (China Metal Market—Alumina & Aluminum, 2010j). Chiping Xinfa Aluminum Co. Ltd. was ordered to shut down approximately 200,000 t/yr of aluminum capacity and 320,000 t/yr of alumina capacity at its smelter and refinery, respectively, in Liaochen, Shangdong Province. The order was issued in July, and the closures were implemented during the third quarter (China Metal Market—Alumina & Aluminum, 2010f).

By early January, Aluminum Corp. of China (Chinalco) restarted all capacity at its primary smelters that had been shut down during fourth quarter of 2008 and first quarter of 2009 (CRU Aluminium Monitor, 2010a). Chinalco also announced it would phase out inefficient capacity of aluminum smelters and alumina refineries by 2011. The permanent closures would involve more than 330,000 t/yr of smelting capacity (CRU Aluminium Monitor, 2010e).

Among the outdated pots being decommissioned by Chinalco was 20,000 t/yr of capacity at the 100,000-t/yr Shandong smelter. Dismantling of the pots started in September (CRU Aluminium Monitor, 2010f). Chinalco also shut down a 176-potline at its Liancheng smelter in Liancheng, Gansu Province in October because its outdated technology was not profitable. The smelter had been commissioned in 2005 (China Metal Market—Alumina & Aluminum, 2010e). In the fourth quarter, Sichuan Meishan Aostar Aluminum Co. Ltd. shut down 50 pots, accounting for about 38,000 t/yr of capacity of the 250,000-t/yr smelter. Increasing prices for power and declining aluminum prices were cited for the closure. Earlier in the year, the smelter had restarted some capacity that had been shut down in late 2008 and early 2009 (China Metal Market—Alumina & Aluminum, 2010p, q).

A transformer fire at the 270,000-t/yr Yichuan Ningdong smelter in Ningxia Autonomous Region in November forced a shutdown. A restart was not expected until early to mid-2011 (CRU Aluminium Monitor, 2010g).

Qinao Aluminum Co. Ltd. (a subsidiary of Shenhuo Group) commissioned a 160,000-t/yr smelter in Qinyang, Henan Province (China Metal Market—Alumina & Aluminum, 2010o). During the first quarter of the year, Meishan Aluminium Co. restarted all capacity that had been shut down during the fourth quarter of 2008. Higher prices and increasing demand enabled the restart (CRU Aluminium Monitor, 2010c).

Chinalco was progressing on several expansions that would add 850,000 t/yr of smelter capacity. Construction of an expansion to 550,000 t/yr from 150,000 t/yr at the Guangxi smelter in Pingguo began in November. The project included an expansion of the adjacent alumina refinery that would increase capacity to 2.5 Mt/yr from 2 Mt/yr. The refinery would also attempt to recover iron oxide from the red mud, with an expected 220,000 t/yr of iron oxides to be recovered (China Metal Market—Alumina and Aluminum, 2010c). Expansion of the Liancheng smelter, expected to be completed in 2011, would add 380,000 t/yr of capacity, and at the Gansu Hualu smelter, 70,000 t/yr of capacity and an upgrade to the carbon anode furnace were expected to be completed in 2011 (China Metal Market—Alumina & Aluminum, 2010d).

In May, Sichuan Aba Aluminum Smelter Co. Ltd. (a subsidiary of Chongqing Bosai Mining Group) started production from an expansion project in Wenchuan, Sichuan Province, that increased capacity to 200,000 t/yr from 110,000 t/yr. Bosai was also constructing an extrusion plant near the smelter to produce value-added products (China Metal Market—Alumina & Aluminum, 2010a). Vimetco NV commissioned the first two phases of the 250,000-t/yr Linfeng smelter during 2010 and had completed the third phase by yearend. The third phase, with a capacity of 80,000 t/yr, was expected to start production in early 2011 (Vimetco NV, 2011). Kaiman Aluminum Co. started production from a new 350,000-t/yr smelter in August. The company, previously known as Coalmine Aluminum Co., operated a 1.8-Mt/yr alumina refinery (Platts Metals Daily, 2010).

Dongyuan Qujing Aluminum Co. Ltd. completed two expansions to its smelter in Qujing, Yunnan Province, during the year that increased the smelter's capacity to 380,000 t/yr from 230,000 t/yr (China Metal Market—Alumina & Aluminum, 2010g). In the western part of China, Xinjiang Wujiaqu Coal & Power Co. Ltd. (a subsidiary of Shandong Chiping Xinfa Group) completed a new smelter with a capacity of 370,000 t/yr and started production in July. A plan to increase capacity of the smelter to 1.6 Mt/yr was being studied. The project also included a captive powerplant using coal mined near the smelter (China Metal Market—Alumina & Aluminum, 2010r). Jinning Aluminum Magnesium New Type Material Co. Ltd. started production from its new smelter in June. The smelter had a capacity of 350,000 t/yr and was located in Zhongning county, Ningxia Hui Autonomous Region. Expansion of the smelter to 1.2 Mt/yr was planned (China Metal Market—Alumina & Aluminum, 2010m).

Germany.—During the first half of the year, Trimet Aluminium AG restarted 15,000 t/yr of capacity at its 170,000-t/yr Essen smelter and 40,000 t/yr of capacity at the 132,000-t/yr Hamburg smelter that had closed in early 2009. Trimet had closed 50,000 t/yr of capacity at the Essen smelter but then restarted 35,000 t/yr of capacity in late 2009. The restarts brought production at both smelters back to full capacity (Trimet Aluminium AG, 2010).

Iceland.—Rio Tinto announced plans to modernize and expand capacity of the ISAL smelter in Straumsvik. The capacity of the smelter would increase to 230,000 t/yr from 190,000 t/yr. The project was expected to be started in April 2012 and be completed by July 2014. The expansion plan was made in conjunction with a long-term power agreement (October 2010 through 2036) with the utility, Landsvirjun (Rio Tinto Alcan Inc., 2010).

Century anticipated restarting construction on the Helguvik smelter by mid-2011 and was awaiting final permits. The project was delayed during the financial crisis in late 2008. Once completed, the smelter would have a production capacity of 360,000 t/yr (Century Aluminum Co., 2010b).

India.—Vedanta Resources plc completed expansion of the Jharsuguda I smelter to 500,000 t/yr from 250,000 t/yr. A power failure in April damaged 171 pots, which were repaired during the year (Vedanta Resources plc, 2010b).

Because of delays in obtaining a mining permit at the Niyamgri bauxite mine, construction of two smelters was temporarily delayed. The 325,000-t/yr Korba III smelter had been progressing towards initial production in the first quarter of 2011 and completion in September 2011. The 125,000-t/yr Jharsuguda II smelter would have been completed in September 2012. Revised completion dates for both projects were not announced (Vedanta Resources plc, 2010a, p. 31, 39; 2010c).

A power failure caused by lightning shut down production at Hindalco's Hirakud smelter in early July. Full production was expected to be restored during the first quarter of 2011. Expansion of the smelter to 161,000 t/yr from 155,000 t/yr was expected to be completed in early 2011. Another expansion to increase capacity to 213,000 t/yr was expected to be completed in March 2012, and a further expansion to 360,000 t/yr was being considered. Construction of the 359,000-t/yr Mahan smelter and 900-MW captive powerplant was expected to be completed in September 2011. Completion of the 359,000-t/yr Aditya smelter and 900-MW captive powerplant was projected for October 2011. Acquisition of land and environmental permits for the proposed 359,000-t/yr Jharkhand smelter and 900-MW captive powerplant was progressing again after having been deferred in 2009. Completion of the project was planned for 2013 (Hindalco Industries Ltd., 2010).

Iran.—Hormzal Aluminum Ltd. commissioned a 147,000-t/yr smelter in Bandar Abbas during the first quarter of the year (CRU Aluminium Monitor, 2010c).

Italy.—Alcoa temporarily closed the Fusina smelter in May. Plans to close the 44,000-t/yr smelter and the 150,000-t/yr Portovesme smelter were announced in November 2009 in response to a ruling by the European Commission that power contracts between Alcoa and the Italian Government were out of compliance with European Union regulations. Alcoa delayed the closures while the ruling was being appealed and negotiations for power contracts were being made with the Italian Government. The Portovesme smelter was continuing to operate (Alcoa Inc., 2010d, p. 2; Kovalyova, 2010).

Kazakhstan.—Construction on an expansion to increase capacity to 250,000 t/yr from 125,000 t/yr at the Pavlodar smelter was completed in May, and all of the new pots were producing by midyear. An anode plant was also under construction, with completion expected in 2011 (CRU Aluminium Monitor, 2010d; Eurasian Natural Resources Group Inc., 2010).

Montenegro.—Central European Aluminum Co. continued with a modernization project of the Podgorica smelter and alumina refinery. Although originally planned for completion by yearend, some work was delayed for completion to early 2011. Capacity of the smelter would increase to 156,000 t/yr from 120,000 t/yr, and capacity of the alumina refinery would increase to 400,000 t/yr from 280,000 t/yr. During the year, about 100 pots which had been shut down because of the price decline during 2008 and 2009 were restarted. These pots accounted for approximately 40,000 t/yr of capacity and bring operating capacity to 130,000 t/yr (Central European Aluminum Co., 2010a; b).

New Zealand.—In December, Rio Tinto cut production at its 350,000-t/yr Tiwai Point smelter by 18,000 t/yr because of rising spot market prices for electricity (10% of the smelter's power was purchased on the spot market). Shipments of billet to the United States were not expected to be affected. Earlier in the year, Rio Tinto had increased billet production to supply customers on the west coast of the United States because of strong demand by extruders (American Metal Market, 2010d; Riley, 2010a).

Norway.—Norsk Hydro announced plans to construct a recycling plant at Karmoy, on the site of the Soderberg potline, which had been decommissioned in March 2009. Two furnaces would be built, each with a capacity of 35,000 t/yr. Casting of the molten metal would take place in the casthouse used by the primary smelter. Construction of the first furnace was expected to begin in early 2011, with operation starting in summer 2012 (Norsk Hydro ASA, 2010e).

Norsk Hydro was planning to make investments to modernize and expand production of hydroelectric power in Norway. Norsk Hydro had ownership in five primary aluminum smelters in Norway, with a combined capacity of almost 950,000 t/yr, that were powered by its system of hydroelectric powerplants.

Construction began on an expansion project at the Holsbru powerplant in August that would increase capacity by 84 gigawatts (GW). Other projects included expansion of the Ilvatn powerplant by 113 GW (2012 to 2015), construction of a 98-GW powerplant at Oyane (2012 to 2014), and modernization projects of five powerplants in the Rjukan region (2011 to 2015) (Norsk Hydro ASA, 2010a, b, f).

Qatar.—A power failure on August 9 forced the shutdown of 444 pots at the Qatar Aluminium Ltd. (Qatalum) smelter in Qatar. The 585,000-t/yr smelter, which was commissioned in December 2009, was still in the ramp-up process at the time of the shutdown. The smelter was expected to reach full production by the end of March 2011. Qatalum was a joint venture between Qatar Petroleum Ltd. (Doha, Qatar) and Norsk Hydro (Norsk Hydro ASA, 2010h, i).

Romania.—Vimetco restarted 35,000 t/yr of 60,000 t/yr of capacity idled in early 2009 at the 300,000-t/yr Slatina smelter. The restart of the pots brought operating capacity to 275,000 t/yr (Vimetco NV, 2011).

Russia.—United Company Rusal restarted an idle potline at the 318,000-t/yr Novokuznetsk smelter in the first quarter of the year. Approximately one-quarter of the smelting capacity was shut down in March 2009 (United Company RUSAL, 2010a). Rusal also increased production from 950,000 t/yr to 980,000 t/yr, at the 1-Mt/yr Krasnoyarsk smelter. Minor increases in production at the Kandalaksha, Nadvoitsy, Sayanogorsk, Volgograd, and Volkhov smelters also took place during the year (United Company RUSAL, 2011a, p. 16 and 32).

Rusal commissioned a new potline at the Irkutsk smelter in April that increased capacity to 460,000 t/yr from 300,000 t/yr. Other investments at the smelter included a new casthouse and an emissions control system (United Company RUSAL, 2010b). Rusal obtained financing and planned to resume construction of the Boguchanskaya smelter and hydroelectric powerplant in early 2011, with completion expected sometime in 2013. When completed, the smelter was expected to have a capacity of 600,000 t/yr. Construction of the 750,000-t/yr Taishet smelter was scheduled to resume in 2011 after being put on hold in 2009 (United Company RUSAL, 2011b).

Saudi Arabia.—In October, Saudi Arabian Mining Co. (Ma'aden) and Alcoa began construction of the 740,000-t/yr Raz as Zawr smelter and 380,000 t/yr rolling mill. The project, expected to be completed in 2013, also included a 4-Mt/yr bauxite mine at Al Ba'itha and 1.8-Mt/yr alumina refinery in Raz as Zawr that were expected to be completed in 2014. Ma'aden owned 74.9% of the joint venture and Alcoa owned 25.1% (Alcoa Inc., 2010e).

Spain.—Alcoa's 93,000-t/yr Aviles smelter was shut down in June as a result of flooding caused by heavy rains (Alcoa Inc., 2010g). The smelter was operating at full capacity by yearend (Alcoa Inc., 2011).

Sweden.—Rusal increased production at the 128,000-t/yr Kubal smelter to 93,000 t/yr. Production from the smelter had been cut to 70,000 t/yr in 2009 as Rusal temporarily shut high-cost capacity (United Company RUSAL, 2011a, p. 16, 32).

United Arab Emirates.—Emirates Aluminuim Ltd. (EMAL) announced that the last of the 756 pots at the 700,000-t/yr smelter started production in December. Production from the first pots started in December 2009. EMAL was a partnership between Dubai Aluminium Co. Ltd. and Mubadala Development Co. (Emirates Aluminium Ltd., 2011).

United Kingdom.—In July, Rio Tinto restarted full production at its 44,000-t/yr smelter in Lochaber, Scotland, and its 169,000-t/yr smelter in Lynemouth, England. The smelters had reduced production in the early part of 2009, but by yearend 2009, production was gradually being restored (Rio Tinto plc, 2010c, p. 15).

Venezuela.—At the beginning of the year, Venalum shut down 145,000 t/yr of capacity at the 430,000-t/yr smelter owing to a power shortage caused by low water levels at the Guri Dam and to low prices for aluminum. Starting in August, Venalum restarted production from 145 of the 394 pots that had been shut down. The company imported aluminum to fill domestic customer orders and reduced exports because of the shutdown (Platts Metals Week, 2010h, i). Alcasa also shut down 115,000 t/yr of its 210,000-t/yr smelter in January as a result of power shortages, including two potlines (50,000 t/yr of capacity) that were permanently shut down because of outdated technology and low productivity. Despite increased power supplies, restart of the temporarily closed pots was delayed as a result of financial issues (Platts Metals Week, 2010b).

Outlook

Aluminum prices generally continued their upward trend in the first quarter of 2011, exceeding the price range of 2006 through mid-2008, but remained volatile. At the end of 2010 and early in 2011, five domestic smelters announced restarts of capacity shut down during the fourth quarter of 2008 and first quarter of 2009. These restarts were generally attributed to new low-cost power contracts combined with recovering aluminum prices. Other domestic capacity that closed during the financial crisis was not expected to restart until producers were more confident in a sustained recovery and could also obtain low-cost power contracts. As of June 1, 2011, about 40% (1.23 Mt/yr) of domestic primary aluminum smelting capacity was not being used. World demand for aluminum in 2011 was expected to remain at levels lower than in 2008 owing to depressed levels in automobile manufacturing and home construction.

Consumer credit issues in the United States and Western Europe were expected to continue through 2011. The continuing uncertainty of the impact of sovereign debt issues in Europe also raised concerns about consumer demand. Global production and consumption had recovered from the decline during the crisis because of the strength of demand in emerging markets, offsetting weakness in developed markets. Decreased demand for aluminum in developed economies still recovering from the economic events of 2008 was expected to continue for several years. Demand for aluminum in emerging economies was expected to increase as these economies continue to improve and recover from the effects of the global recession. However, policies aimed at slowing growth in China may slow the rate of growth of demand for aluminum in that nation.

Easing of credit to aluminum companies was expected to enable more expansion projects to resume progress in many parts of the world, following the lead of projects in regions with low power costs already moving forward. Relatively high electricity prices in parts of the United States diminished the likelihood of some domestic smelters reopening in the near-term. New smelters constructed where power costs are relatively low were expected to continue to replace production at high-cost smelters in the United States and other locations.

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TABLE 1
SALIENT ALUMINUM STATISTICS[1]

(Thousand metric tons unless otherwise specified)

		2006	2007	2008	2009	2010
United States:						
Primary production:						
Quantity		2,284	2,554	2,658	1,727	1,726
Value	millions	$6,110	$6,880	$7,060	$3,030	$3,980
Price, average, U.S. market, spot	cents per pound	121.4	122.2	120.5	79.4	104.4
Inventories (December 31):						
Aluminum industry[2]		1,410	1,400	1,220	937	1,010
London Metal Exchange, U.S. warehouses[3]		228	463	1,290	2,200	2,230
Secondary recovery:[4]						
New scrap		2,800 r	2,450 r	2,130 r	1,570 r	1,550
Old scrap		1,580 r	1,660 r	1,500 r	1,260 r	1,250
Total		4,380 r	4,120 r	3,630 r	2,820 r	2,800
Exports, crude and semicrude		2,820	2,840	3,280	2,710	3,040
Imports for consumption, crude and semicrude		4,660	4,020	3,710	3,680	3,610
Supply, apparent[5]		8,500 r	7,620 r	6,070 r	4,890 r	5,000
Consumption, apparent[6]		5,700 r	5,170 r	3,940 r	3,320 r	3,460
World, production		33,900	38,000 r	39,600	36,900 r	40,800 e

e Estimated. r Revised.

[1] Data are rounded to no more than three significant digits except "Primary production: Quantity" and "Price, average, U.S. market, spot."

[2] Data from the Aluminum Association Inc.; includes ingot, semifabricated material, and scrap inventory levels for United States and Canadian producers.

[3] Includes aluminum alloyed material.

[4] Metallic recovery from purchased, tolled, or imported new and old scrap expanded for full industry coverage.

[5] Defined as domestic primary metal production plus secondary recovery plus imports (excluding scrap) minus exports plus adjustments for London Metal Exchange (U.S. warehouses) and industry stock changes.

[6] Apparent supply less recovery from purchased new scrap.

TABLE 2

PRIMARY ANNUAL ALUMINUM PRODUCTION CAPACITY IN THE UNITED STATES, BY COMPANY[1]

	Yearend capacity (thousand metric tons)		
Company and location	2009	2010	Ownership in 2010
Alcoa Inc.:			
Alcoa, TN[2]	215	215	Alcoa Inc., 100%.
Badin, NC[3]	60 [r]	--	Do.
Evansville, IN (Warrick)	309	309	Do.
Ferndale, WA (Intalco)	279 [r]	279	Do.
Frederick, MD (Eastalco)[3]	195	--	Do.
Massena, NY (St. Lawrence)[2]	125	125	Do.
Massena, NY	130	130	Do.
Mount Holly, SC	229 [r]	229	Alcoa Inc., 50.3%; Century Aluminum Co., 49.7%.
Rockdale, TX[2]	267	267	Alcoa Inc., 100%.
Wenatchee, WA	184	184	Do.
Total	1,990 [r]	1,740	
Century Aluminum Co.:			
Hawesville, KY	244	244	Century Aluminum Co., 100%.
Ravenswood, WV[2]	170	170	Do.
Total	414	414	Do.
Columbia Falls Aluminum Co., Columbia Falls, MT[2]	168	168	Glencore International AG, 100%.
Goldendale Aluminum Co., Goldendale, WA[2]	160	160	Private interest, 60%; employees, 40%.
Noranda Aluminum Holding Corp., New Madrid, MO	250	263	Noranda Aluminum Holding Corp., 100%.
Ormet Primary Aluminum Corp., Hannibal, OH	265	265	Ormet Corp., 100%.
Rio Tinto Alcan Inc., Sebree, KY	196	196	Rio Tinto Alcan Inc., 100%.
Grand total	3,450 [r]	3,200	

[r] Revised. Do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Temporarily idle.

[3] Smelter facilities have been permanently idled. This capacity is no longer reflected in Alcoa's portfolio.

TABLE 3

U.S. CONSUMPTION OF AND RECOVERY FROM PURCHASED NEW AND OLD ALUMINUM SCRAP, BY CLASS[1, 2]

(Metric tons)

		Calculated recovery	
Class	Consumption	Aluminum	Metallic
2009:			
Secondary smelters	1,450,000 [r]	1,020,000 [r]	1,090,000 [r]
Independent mill fabricators[3]	1,620,000 [r]	1,390,000 [r]	1,470,000 [r]
Foundries	74,800	61,200	65,400
Other consumers	6,870	6,330	6,350
Total	3,160,000 [r]	2,470,000 [r]	2,630,000 [r]
Estimated full industry coverage	3,390,000 [r]	2,650,000 [r]	2,820,000 [r]
2010:			
Secondary smelters	1,610,000	1,150,000	1,230,000
Independent mill fabricators[3]	1,450,000	1,240,000	1,320,000
Foundries	50,700	41,400	44,200
Other consumers	6,290	6,290	6,290
Total	3,120,000	2,430,000	2,590,000
Estimated full industry coverage	3,370,000	2,620,000	2,800,000

[r] Revised.

[1] Excludes recovery from other than aluminum-base scrap.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Includes plants previously categorized as "Integrated aluminum companies."

TABLE 4
U.S. STOCKS, RECEIPTS, AND CONSUMPTION OF PURCHASED NEW AND OLD ALUMINUM SCRAP AND SWEATED PIG IN 2010[1, 2]

(Metric tons)

Class of consumer and type of scrap	Stocks, January 1	Net receipts[3]	Consumption	Stocks, December 31
Secondary smelters:				
New scrap:				
Extrusions	15,700	296,000	295,000	16,200
Can stock clippings	2,960 r	72,800	71,200	4,520
Other wrought sheet and clippings	1,800 r	196,000	195,000	2,510
Casting	594 r	61,100	60,400	1,350
Borings and turnings	2,040 r	84,300	84,100	2,260
Dross and skimmings	7,020 r	407,000	407,000	6,890
Total	30,100 r	1,120,000	1,110,000	33,800
Old scrap:				
Castings	3,610 r	137,000	137,000	4,040
Extrusion	3,320 r	95,800	96,100	2,970
Aluminum cans[4]	8,740	116,000	118,000	7,060
Other wrought products	6,740 r	73,200	75,800	4,080
Auto shredder scrap	938 r	67,600	67,500	1,010
Total	23,300 r	490,000	494,000	19,200
Sweated pig	106	1,750	1,770	89
Grand total secondary smelters	53,500 r	1,610,000	1,610,000	53,000
Integrated aluminum companies, foundries, independent mill fabricators, other consumers:				
New scrap:				
Extrusion	14,600 r	251,000	263,000	3,020
Can stock clippings	608	187,000	186,000	1,530
Other wrought sheet and clippings	3,610 r	182,000	182,000	3,950
Casting	243	17,100	17,100	243
Borings and turnings	367	11,900	11,900	367
Dross and skimmings	452	4,370	4,360	462
Total	19,900 r	654,000	664,000	9,570
Old scrap:				
Castings	2,620	130,000	127,000	5,570
Extrusion	17	8,120	8,120	17
Aluminum cans[4]	3,050	533,000	522,000	13,700
Other wrought products	381	139,000	139,000	381
Auto shredder scrap	82	454	454	82
Other	--	46,300	46,300	--
Total	6,150	857,000	843,000	19,700
Grand total integrated aluminum companies, etc.	26,100 r	1,510,000	1,510,000	29,300
All scrap consumed:				
New scrap:				
Extrusion	30,300 r	547,000	558,000	19,200
Can stock clippings	3,560	260,000	258,000	6,050
Other wrought sheet and clippings	5,410 r	378,000	377,000	6,460
Casting	836	78,300	77,500	1,600
Borings and turnings	2,400	96,200	96,000	2,630
Dross and skimmings	7,470	412,000	412,000	7,350
Total	50,000 r	1,770,000	1,780,000	43,300
Old scrap:				
Castings	6,230	267,000	264,000	9,620
Extrusion	3,330	104,000	104,000	2,990
Aluminum cans[4]	11,800	649,000	640,000	20,700
Other wrought products	7,120	212,000	215,000	4,460
Auto shredder scrap	1,020	68,000	68,000	1,090

See footnotes at end of table.

TABLE 4—Continued
U.S. STOCKS, RECEIPTS, AND CONSUMPTION OF PURCHASED NEW AND OLD ALUMINUM SCRAP AND SWEATED PIG IN 2010[1, 2]

(Metric tons)

Class of consumer and type of scrap	Stocks, January 1	Net receipts[3]	Consumption	Stocks, December 31
Old scrap—Continued:				
Other	--	46,300	46,300	--
Total	29,500	1,350,000	1,340,000	38,900
Sweated pig	106	1,750	1,770	89
Grand total of all scrap consumed	79,600 [r]	3,120,000	3,120,000	82,300

[r] Revised. -- Zero.

[1] Includes imported scrap. According to reporting companies, 5.60% of total receipts of aluminum-base scrap, or 172,000 metric tons, was received on toll arrangements.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Includes inventory adjustment.

[4] Used beverage cans toll treated for primary producers are included in secondary smelter tabulation.

TABLE 5
PRODUCTION AND SHIPMENTS OF SECONDARY ALUMINUM ALLOYS BY INDEPENDENT SMELTERS IN THE UNITED STATES[1]

(Metric tons)

	2009		2010	
	Production	Net shipments[2]	Production	Net shipments[2]
Diecast alloys:				
13% Si, 360, etc. (0.6% Cu, maximum)	38,200 [r]	38,200 [r]	37,500	37,100
380 and variations	114,000 [r]	114,000 [r]	214,000	215,000
Sand and permanent mold:				
95/5 Al-Si, 356, etc. (0.6% Cu, maximum)	36,200 [r]	35,500 [r]	39,100	39,200
No. 12 and variations	953 [r]	953 [r]	943	943
No. 319 and variations	37,300 [r]	36,000 [r]	80,600	81,100
F-132 alloy and variations	7,420 [r]	7,390 [r]	9,380	8,880
Al-Mg alloys	7,240 [r]	7,200 [r]	7,240	7,240
Al-Zn alloys	1,660 [r]	1,680 [r]	1,650	1,650
Al-Si alloys (0.6% to 2.0% Cu)	3,230 [r]	3,090 [r]	3,190	3,190
Al-Cu alloys (1.5% Si, maximum)	513 [r]	513 [r]	445	445
Al-Si-Cu-Ni alloys	5,920 [r]	5,920 [r]	6,620	6,620
Other	136	136	136	136
Wrought alloys, extrusion billets	372,000	379,000 [r]	491,000	489,000
Miscellaneous:				
Steel deoxidation	31,900 [r]	31,900 [r]	22,300	22,100
Pure (97.0% Al)	W	W	W	W
Aluminum-base hardeners	W	W	W	W
Other[3]	51,500	48,800	38,400	38,700
Total	708,000 [r]	710,000 [r]	953,000	951,000
Less consumption of materials other than scrap:				
Primary aluminum	98,800 [r]	XX	153,000	XX
Primary silicon	14,100 [r]	XX	20,800	XX
Other	9,300 [r]	XX	12,700	XX
Net metallic recovery from aluminum scrap and sweated pig consumed in production of secondary aluminum ingot[4]	586,000 [r]	XX	766,000	XX

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous, other." XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes inventory adjustment.

[3] Includes other diecast alloys.

[4] No allowance made for melt loss of primary aluminum and alloying ingredients.

TABLE 6
DISTRIBUTION OF END-USE SHIPMENTS OF ALUMINUM PRODUCTS IN THE UNITED STATES AND CANADA, BY INDUSTRY[1]

Industry	2009		2010^p	
	Quantity (thousand metric tons)	Percentage of grand total	Quantity (thousand metric tons)	Percentage of grand total
Containers and packaging	2,150	26.5	2,200	22.4
Building and construction	964	11.9	1,000	10.2
Transportation	1,910	23.7	2,800	28.6
Electrical	593	7.3	700	7.1
Consumer durables	458	5.7	600	6.1
Machinery and equipment	475	5.9	700	7.1
Other markets	254	3.1	300	3.1
Total	6,810	84.1	8,300	84.7
Exports^e	1,280	15.9	1,500	15.3
Grand total	8,090	100.0	9,800	100.0

^{e}Estimated. ^{p}Preliminary.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: The Aluminum Association Inc.

TABLE 7
U.S. NET SHIPMENTS OF ALUMINUM WROUGHT AND CAST PRODUCTS, BY PRODUCERS[1, 2]

(Thousand metric tons)

	2008	2009	2010^p
Wrought products:[3]			
Sheet, plate, foil	4,770	4,050	4,700
Pipe, tube, extruded shapes	1,380	1,070	1,400
Rod, bar, wire, cable	626	514	600
Forgings (including impacts)	102	73	100
Powder, flake, paste	61	45	60
Total	6,940	5,750	6,860
Castings:			
Sand	255	160	250
Permanent and semipermanent mold	570	371	570
Die	1,030	691	1,000
Other	44	6	40
Total	1,900	1,230	1,860
Grand total	8,830	6,980	8,720

^{p}Preliminary.

[1] Net shipments derived by subtracting the sum of producers' domestic receipts of each mill shape from the domestic industry's gross shipments of that shape.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Wrought products data series includes net shipments in both the United States and Canada.

Source: The Aluminum Association Inc.

TABLE 8
ALUMINUM PRICES

(Dollars per pound)

Material	2009	2010
Primary aluminum, average:[1]		
U.S. market	0.794	1.044
LME cash price	0.755	0.986
NASAAC cash price, average	0.653 r	0.949
Secondary alloy, yearend:[2]		
A319 (3% Cu)	1.055	1.170
A380 (3% Zu)	1.055 r	1.115
A360 (0.6% Cu)	1.065	1.210
A413 (0.6% Cu)	1.065	1.210
Scrap, yearend:[2]		
Clean, dry turnings	0.60–0.61	0.70–0.72
Mixed low–copper–content clips	0.67–0.68	0.78–0.81
Old sheet and castings	0.62–0.63	0.72–0.76
Used beverages cans	0.71–0.73	0.83–0.86

[r] Revised.

[1] Source: Platts Metals Week.

[2] Source: American Metal Market.

TABLE 9
U.S. EXPORTS OF ALUMINUM, BY CLASS[1]

	2009		2010	
Class	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	262,000	$514,000	284,000	$709,000
Scrap	1,660,000	2,120,000	1,910,000	3,190,000
Plates, sheets, bars, strip, etc.	739,000	2,830,000	786,000	3,230,000
Castings and forgings	18,900	218,000	20,000	250,000
Semifabricated forms, n.e.c.	31,100	226,000	36,200	269,000
Total	2,710,000	5,910,000	3,040,000	7,650,000
Manufactures:				
Foil and leaf	72,000	323,000	79,600	376,000
Powders and flakes	4,470	24,100	5,520	31,400
Wire and cable	45,900	132,000	43,200	163,000
Total	122,000	479,000	128,000	570,000
Grand total	2,830,000	6,390,000	3,170,000	8,220,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 10

U.S. EXPORTS OF ALUMINUM, BY COUNTRY[1]

Country	Metals and alloys, crude		Plates, sheets, bars, etc.[2]		Scrap		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009:								
Brazil	59	$449	11,900	$66,500	5,360	$7,130	17,300	$74,100
Canada	69,600	135,000	300,000	1,010,000	107,000	169,000	476,000	1,310,000
China	21,600	31,900	38,400	215,000	1,010,000	1,260,000	1,070,000	1,510,000
France	710	2,830	9,240	63,100	3	11	9,950	66,000
Germany	4,860	12,800	9,820	72,000	326	743	15,000	85,500
Hong Kong	1,620	3,880	9,090	36,600	76,800	111,000	87,500	151,000
Italy	1,170	4,320	2,370	26,100	--	--	3,540	30,400
Japan	10,500	19,600	8,650	95,500	21,100	31,800	40,200	147,000
Kazakhstan	--	--	27	276	--	--	27	276
Korea, Republic of	1,870	3,930	10,900	80,800	160,000	197,000	173,000	282,000
Mexico	123,000	243,000	249,000	915,000	91,600	148,000	464,000	1,310,000
Netherlands	97	599	711	9,890	315	407	1,120	10,900
Philippines	3	19	282	3,350	--	--	284	3,370
Russia	3	36	113	993	--	--	116	1,030
Saudi Arabia	238	606	26,100	123,000	--	--	26,400	124,000
Singapore	16,500	32,400	1,440	13,300	421	586	18,400	46,300
South Africa	12	43	147	2,200	--	--	159	2,250
Taiwan	2,460	4,240	2,910	20,400	100,000	103,000	106,000	128,000
Thailand	115	234	7,990	28,900	5,940	7,890	14,000	37,000
Ukraine	--	--	6	59	22	13	27	72
United Kingdom	769	3,440	10,000	93,000	572	1,720	11,400	98,100
Venezuela	41	546	361	2,270	718	1,000	1,120	3,820
Other	6,430 [r]	14,800	90,100 [r]	394,000 [r]	80,300	82,300	177,000	491,000 [r]
Total	262,000	514,000	789,000	3,270,000	1,660,000	2,120,000	2,710,000	5,910,000
2010:								
Brazil	1,080	2,830	14,300	79,600	4,890	9,060	20,300	91,500
Canada	88,800	217,000	361,000	1,360,000	125,000	233,000	575,000	1,810,000
China	3,910	8,590	32,600	200,000	1,220,000	2,030,000	1,250,000	2,240,000
France	1,480	5,180	11,200	80,300	932	1,840	13,600	87,300
Germany	3,170	8,780	9,680	70,600	498	1,600	13,300	81,000
Hong Kong	109	311	10,800	47,900	53,000	83,000	63,800	131,000
Italy	36	261	2,490	28,600	19	66	2,540	28,900
Japan	1,810	7,430	8,730	106,000	23,800	49,100	34,300	162,000
Kazakhstan	--	--	6	279	--	--	6	279
Korea, Republic of	454	2,140	15,100	107,000	155,000	230,000	171,000	339,000
Mexico	174,000	425,000	258,000	1,040,000	153,000	323,000	586,000	1,790,000
Netherlands	190	629	733	8,680	448	838	1,370	10,200
Philippines	3	25	336	4,760	--	--	339	4,780
Russia	1	8	90	900	--	--	91	908
Saudi Arabia	9	49	16,800	60,100	9	17	16,900	60,100
Singapore	726	2,790	2,820	26,700	426	629	3,970	30,100
South Africa	9	80	346	2,750	--	--	356	2,820
Taiwan	2,080	5,400	5,960	32,400	107,000	125,000	115,000	163,000
Thailand	30	214	1,390	13,000	5,070	8,380	6,490	21,600
Ukraine	--	--	(3)	6	--	--	(3)	6
United Kingdom	639	2,370	9,780	89,000	598	1,260	11,000	92,600
Venezuela	6	74	547	4,600	--	--	553	4,670
Other	5,270	19,600	78,900	393,000	66,700	90,900	151,000	504,000
Total	284,000	709,000	842,000	3,750,000	1,910,000	3,190,000	3,040,000	7,650,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes castings, forgings, and unclassified semifabricated forms.

(3) Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 11

U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM, BY CLASS[1]

Class	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	2,900,000	$4,960,000	2,650,000	$6,110,000
Plates, sheets, strip, etc., n.e.c.[2]	499,000	1,550,000	666,000	2,270,000
Pipes, tubes, etc.	33,400	190,000	27,500	210,000
Rods and bars	254,000	783,000	274,000	899,000
Scrap	433,000	503,000	504,000	763,000
Total	4,110,000	7,980,000	4,120,000	10,300,000
Manufactures:				
Foil and leaf[3]	102,000	389,000	126,000	497,000
Powders and flakes	5,710	22,200	10,100	45,100
Wire	156,000	321,000	145,000	387,000
Total	264,000	732,000	281,000	930,000
Grand total	4,380,000	8,710,000	4,400,000	11,200,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes circles, disks, plates, and sheets.

[3] Excludes etched capacitor foil.

Source: U.S. Census Bureau.

TABLE 12

U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM, BY COUNTRY[1]

	Metals and alloys, crude		Plates, sheets, bars, etc.[2]		Scrap		Total	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009:								
Argentina	164,000	$269,000	2	$32	--	--	164,000	$269,000
Australia	7,500	13,600	44	581	--	--	7,550	14,200
Bahrain	1,690	4,400	9,860	28,100	--	--	11,600	32,500
Belgium	178	685	2,180	9,540	26	$56	2,380	10,300
Brazil	106,000	183,000	15,000	33,500	--	--	121,000	216,000
Canada	2,020,000	3,490,000	261,000	772,000	293,000	328,000	2,570,000	4,590,000
China	1,890	3,570	250,000	668,000	9	39	252,000	672,000
France	1,520	8,970	1,710	17,800	35	335	3,260	27,100
Germany	579	2,270	61,200	309,000	413	883	62,200	312,000
Italy	(3)	23	3,540	21,300	97	79	3,630	21,400
Japan	492	1,210	8,900	42,900	414	1,340	9,800	45,400
Korea, Republic of	2,330	4,000	1,580	7,430	105	157	4,010	11,600
Mexico	18,400	68,800	13,400	63,000	95,700	120,000	128,000	252,000
Netherlands	210	859	1,560	9,780	2,150	2,800	3,920	13,400
Norway	442	926	14	412	--	--	457	1,340
Panama	197	298	--	--	1,640	1,830	1,840	2,120
Russia	353,000	548,000	16,700	67,300	1,740	2,970	371,000	618,000
South Africa	52,900	76,000	37,800	97,700	27	28	90,700	174,000
Tajikstan	6,690	8,260	--	--	--	--	6,690	8,260
United Arab Emirates	48,300	93,800	--	--	16	18	48,300	93,900
United Kingdom	355	1,290	4,760	24,000	8,840	9,280	14,000	34,600
Venezuela	84,400	131,000	6,250	10,700	8,390	12,700	99,100	155,000
Other	23,800 r	43,200 r	90,100 r	336,000 r	20,300	22,200	134,000 r	401,000 r
Total	2,900,000	4,960,000	786,000	2,520,000	433,000	503,000	4,110,000	7,980,000
2010:								
Argentina	138,000	288,000	3	38	--	--	138,000	288,000
Australia	28,400	68,600	119	1,040	103	141	28,600	69,800
Bahrain	--	--	16,600	47,400	6	3	16,600	47,400
Belgium	102	379	2,000	9,820	1	5	2,110	10,200
Brazil	57,300	131,000	14,200	38,700	282	506	71,800	171,000
Canada	1,920,000	4,490,000	316,000	1,010,000	343,000	519,000	2,580,000	6,110,000
China	1,220	3,680	272,000	782,000	77	248	273,000	786,000
France	1,610	9,740	2,940	25,900	53	392	4,590	36,000
Germany	970	3,710	68,600	331,000	231	862	69,800	336,000
Italy	199	427	3,560	24,500	227	169	3,980	25,100
Japan	901	2,000	7,110	44,800	693	1,520	8,710	48,300
Korea, Republic of	2,490	6,840	2,240	11,500	143	385	4,870	18,700
Mexico	24,100	84,000	22,000	110,000	107,000	156,000	153,000	351,000
Netherlands	390	1,490	1,920	12,900	553	885	2,870	15,300
Norway	2,100	4,750	80	457	128	223	2,300	5,430
Panama	502	1,010	14	50	2,320	3,890	2,840	4,950
Russia	203,000	449,000	14,700	68,800	--	--	218,000	518,000
South Africa	14,300	29,500	49,000	158,000	--	--	63,300	187,000
United Arab Emirates	81,700	195,000	5	20	71	125	81,800	195,000
United Kingdom	437	1,940	7,250	32,400	7,890	13,400	15,600	47,700
Venezuela	123,000	251,000	2,480	5,230	1,940	3,340	127,000	260,000
Other	41,700	88,700	161,000	566,000	40,100	62,400	243,000	717,000
Total	2,650,000	6,110,000	967,000	3,380,000	504,000	763,000	4,120,000	10,300,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes circles, disks, pipes, rods, tubes, etc.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 13
ALUMINUM, PRIMARY: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2006	2007	2008	2009	2010[e]
Argentina	273	271	394	410 [r]	415
Australia	1,932	1,957	1,974	1,943	1,928 [3]
Azerbaijan	32	39	40	30	30
Bahrain	872	865	872	848 [r]	870
Bosnia and Herzegovina[4]	121 [r]	122	123 [e]	96	118
Brazil	1,605	1,655	1,661	1,536	1,536 [p, 3]
Cameroon	88 [e]	87	91	73	76 [3]
Canada	3,051	3,083	3,120	3,030	2,963 [3]
China[e]	9,360	12,600	13,200	12,900	16,200
Egypt	252	258	260	265	266
France	442	428	389	345	356 [3]
Germany	516	551	606	292	394
Ghana	8	--	--	--	--
Greece	163	166	160	130 [r]	130
Hungary[e]	34	--	--	--	--
Iceland[5]	320	398	787	785	780
India[6]	1,105	1,222	1,308	1,400	1,450
Indonesia[6]	250	242	243	250	252
Iran[e]	205	216	248	250	250
Italy	194	183	180 [e]	171 [r]	168
Japan[7]	7	7 [e]	7	7	6
Kazakhstan	--	12 [r]	106	127	227 [3]
Montenegro	122	124	107	64	80
Mozambique	564	564	536	545	557 [3]
Netherlands	312	301	301 [e]	300	300
New Zealand	337	353	316	271	344 [3]
Nigeria	--	--	11	13	21 [3]
Norway	1,331	1,357	1,358	1,130	800
Oman	--	--	49	351	367 [3]
Poland[8]	58	54 [r]	48	-- [r]	--
Qatar	--	--	--	10	190
Romania[9]	256	283	265	201 [r]	207 [3]
Russia	3,718	3,955	4,190	3,815	3,947 [3]
Slovakia[6]	158	160	163	150	163
Slovenia[4]	118	111	83	35 [r]	40 [3]
South Africa	895 [r]	899 [r]	811	809	807 [3]
Spain	349	408	408 [e]	360 [r]	340
Sweden	101	98	112	70	93 [3]
Switzerland	12	--	--	--	--
Tajikistan	414	419	339	359	349 [3]
Turkey[e]	60	65	65	35 [r, e]	60
Ukraine[9]	113	113	113	50	25
United Arab Emirates	861	890	948	1,010	1,400
United Kingdom	360	365	326	253	186 [3]
United States	2,284	2,554	2,658	1,727	1,726 [3]
Venezuela[e]	610	610	610	410 [r]	335
Total	33,900	38,000 [r]	39,600	36,900 [r]	40,800

See footnotes at end of table.

TABLE 13

ALUMINUM, PRIMARY: WORLD PRODUCTION, BY COUNTRY[1, 2]

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[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Primary aluminum is defined as "The weight of liquid aluminum as tapped from pots, excluding the weight of any alloying materials as well as that of any metal produced from either returned scrap of remelted material." International reporting practices vary from country to country, some nations conforming to the foregoing definition and others using different definitions. For those countries for which a different definition is given specifically in the source publication, that definition is provided in this table by footnote. Table includes data available through May 24, 2011.

[3] Reported figure.

[4] Primary ingot plus secondary ingot.

[5] Ingot and rolling billet production.

[6] Primary ingot.

[7] Excludes high purity aluminum containing 99.995% or more as follows, in metric tons: 2006—49,667; 2007—50,777; 2008—52,000 (revised); 2009—33,000 (revised); and 2010—45,000 (estimated).

[8] Primary unalloyed ingot plus secondary unalloyed ingot.

[9] Primary unalloyed metal plus primary alloyed metal, thus including weight of alloying material.

ANTIMONY

By James F. Carlin, Jr.

Domestic survey data and tables were prepared by Hoa P. Phamdang, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

A single company in the United States, in Montana, produced primary antimony metal and antimony oxide by upgrading imported antimony trioxide to a higher purity. Secondary antimony was recovered in lead alloy from scrapped lead-acid batteries at secondary lead smelters. The amount of antimony used by battery manufacturers was substantially lower than it was 10 years ago because of changing material requirements for batteries.

In 2010, about 36% of the primary antimony used in the United States was in flame retardants; most of the rest was used by the ceramic, chemical, glass, and transportation industries (table 3). Secondary antimony, which was derived almost entirely from recycled lead-acid batteries and contained in antimonial lead, was used in the manufacture of new batteries.

Antimony was mined as a principal product or was a byproduct of the smelting of base-metal ores in 10 countries. Nearly all the world's primary antimony was mined in China (90%). Bolivia (3%), followed by Russia and South Africa (2% each), rounded out the world's top producers (table 9).

Production

Mine.—Stockpile Reserves LLC (Lovelock, NV) had no production in 2010 from its reactivated Fencemaker Mine, 80 kilometers southeast of Lovelock. The mine produced a small amount of antimony-in-concentrate in 2007, which was the first domestic antimony mine production since 2000. The mine had a long history of intermittent antimony production dating back to the 1880s. Stockpile Reserves continued to seek additional funding and cooperated with the Nevada regulatory authorities regarding required licenses and permits (Richard E. Brown, chief executive officer, Stockpile Reserves LLC, written commun., November 23, 2010).

Smelter.—The United States has only one antimony smelter, U.S. Antimony Corp. (USAC) (Thompson Falls, MT). USAC produced antimony metal for bearings, lead alloys, and ordnance; antimony oxide as a raw material for flame retardants; and sodium antimonite for glass and other applications. USAC also recycled antimony-containing products that would otherwise be taken to landfill sites.

Consumption

Of the 134 companies to which a U.S. Geological Survey antimony consumption survey was sent, 66 firms responded. Consumption data were estimated for the remaining 68 firms.

In 2010, consumption (reported and estimated) of primary antimony increased by 32% from that in 2009 (table 2). Both the nonmetal producers and the flame retardants usage categories registered significant increases, while the metal products category showed a modest increase. Industry sources attributed the increases to higher demand in selected commercial sectors (table 3).

Lead-antimony alloys were used in ammunition, antifriction bearings, cable sheaths, corrosion-resistant pumps and pipes, roof sheet solder, and tank lining. Antimony trioxide was used to enhance the flame-retardant properties of plastics, rubber and textiles, and other combustibles. Antimony was also used as a decolorizing and refining agent in the manufacture of some forms of glass, such as optical glass.

Prices

In 2010, the average Platts Metals Week New York dealer price of antimony was $4.01 per pound, an increase of 70% compared with that in 2009 (table 1). The antimony price started the year at $2.85 per pound to $2.95 per pound and generally rose steadily through the year to finish December at $5.50 to $5.70 per pound. Industry sources attributed the marked price advance to an increase in world consumption as well as the closure of several antimony mines in China.

Foreign Trade

U.S. imports of antimony in 2010 were, as has been the case in the recent past, much larger than exports—about 10-fold larger (tables 5–8). Imports of antimony were 26,200 metric tons (t), an increase of 30% compared with that in 2009. China was the leading supplier to the United States of antimony oxide, followed by Belgium, Mexico, and Bolivia, in descending order (tables 7–8).

World Review

Chile.—Mandalay Resources Corp. (Toronto, Ontario, Canada) announced that it had started stockpiling silver-gold-antimony-bearing ore from the Dagny vein at its Cerro Bayo Mine in Patagonia. The Dagny vein was being developed separately from the Fabiola vein, which had started producing ore earlier. The company also commenced drilling at the Yasna vein, with the goal of adding significantly to the 69,000 metric tons per year (t/yr) of ore resources from the Dagny and the Fabiola veins. A fourth vein, Delia NW, was being permitted, with initial development scheduled for mid-2011. Mandalay's goals were to produce 1,870 kilograms per year of gold and 1,500 t/yr of antimony from Cerro Bayo. The Cerro Bayo mining and concentrator complex, acquired while in a care-and-maintenance status from Coeur d'Alene Mines Corp. in August 2010, was in the process of a restart by Mandalay, with plans to ramp up to its design production rate of 700 metric tons per day of ore by yearend 2011. The concentrator was scheduled to commence operation in the first quarter of 2011 (Mandalay Resources Corp., 2010; Metal-Pages, 2010).

China.—The Government set the 2010 antimony production quota at 100,000 t compared with 90,180 t in 2009, including 62,520 t for primary production and 30,480 t for recycling. The primary production quotas were allocated to producers in the provinces, but the recycling quotas were not yet allocated. Also, the Government stated that it would not approve any new projects for antimony, rare earths, or tungsten mining before June 30, 2011 (Ryan's Notes, 2010a).

Chinese authorities were concerned that too much antimony was leaving the country in the form of refined metal rather than being processed into downstream products such as antimony trioxide. Reports indicated that the authorities were restricting antimony metal exports but that large quantities of antimony also were imported into China. Other events resulted in additional restrictions on Chinese antimony metal exports. Local regulators imposed stricter inspections on metal-producing plants following a serious lead poisoning accident in Chenzhou, Hunan Province. Almost all antimony smelters in China's leading antimony-producing area, Lengshuijiang (where Hsikwangshan Twinkling Star Co. Ltd., China's leading antimony producer, was located), were expected to be closed for safety inspections. In addition, antimony production in Yunnan Province was disrupted by a serious drought that affected the power and water supply (Ryan's Notes, 2010b).

Mexico.—USAC completed the construction of a flotation mill at San Antonio de la Cal in the Municipio of Toliman. Although the permits to construct and operate the facility were obtained, the Governor of the State of Queretaro declared that he would not allow the plant to operate because of the designation of a nearby area as a UNESCO World Heritage site. The plant has a production capacity of 150 metric tons per day. USAC was moving the mill to the neighboring State of Guanajuato. The plant was to process the rock for the Los Juarez, Soyatal, and other properties (U.S. Antimony Corp., 2011).

Outlook

The use of antimony as an ingredient in flame retardants is expected to remain its principal use, in global as well as for U.S. markets.

Antimony recovered from scrap has long been an important part of the total antimony supply domestically, but the recovery decline during the past 30 or more years is expected to continue, though at a more moderate rate. Following the advent in the 1970s of low-maintenance and maintenance-free automotive batteries, the antimony content of a typical automotive lead-acid battery has declined to about 0.6% or lower during 2001 through 2010.

In recent years, lead-acid battery manufacturers have initiated research and development programs that could ultimately lead to significant changes in lead-acid battery design. This research has already yielded performance improvements that would make lead-acid batteries viable options for future generation vehicles. The introduction of new lead-acid battery technologies for use in the hybrid vehicle market will likely require a different amount of lead per battery than conventional lead-acid batteries and could eventually reduce or eliminate the use of antimony in lead-acid batteries.

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TABLE 1
SALIENT ANTIMONY STATISTICS[1]

(Metric tons of antimony content unless otherwise specified)

		2006	2007	2008	2009	2010
United States:						
Mine production		--	W	--	--	--
Smelter production:						
Primary		W	W	W	W	W
Secondary		3,520	3,480	3,180	3,020	3,520
Exports:						
Metal, alloys, waste and scrap	gross weight	459	305	366	385	427
Antimony oxide[2]		1,680	1,640	1,830	1,710	2,120
Imports for consumption		23,200	21,900	29,000	20,200	26,200
Reported industrial consumption, primary antimony		10,500 r	9,690 r	8,140	6,770	8,910
Stocks, primary antimony, all classes, December 31		2,120	1,900	1,490	1,420	1,560
Price, average[3]	cents per pound	238.0	257.3	279.5	235.6	401.2
World, mine production		173,000	180,000	182,000	154,000 r	167,000 e

eEstimated. rRevised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Antimony content is calculated by the U.S. Geological Survey.

[3] New York dealer price for 99.5% to 99.6% metal, cost, insurance, freight U.S. ports.

TABLE 2
REPORTED INDUSTRIAL CONSUMPTION OF PRIMARY ANTIMONY IN THE UNITED STATES[1]

(Metric tons of antimony content)

Class of material consumed	2009	2010
Metal	1,160	1,390
Oxide	4,990 r	6,890
Other[2]	616	636
Total	6,770	8,910

rRevised.

[1] Data are rounded to no more than three significant digits: may not add to totals shown.

[2] Includes residues and sulfide.

TABLE 3
REPORTED INDUSTRIAL CONSUMPTION OF PRIMARY ANTIMONY IN THE UNITED STATES, BY PRODUCT[1]

(Metric tons of antimony content)

Product	2009	2010
Metal products:		
Antimonial lead	W	W
Bearing metal and bearings	14	26
Solder	44	34
Other[2]	1,950	2,130
Total	2,000	2,190
Nonmetal products:		
Ammunition primers	W	W
Ceramics and glass	W	W
Pigments	403	399
Plastics	W	W
Other[3]	2,030	3,140
Total	2,430	3,540
Flame retardants:		
Adhesives	217	213
Plastics	1,820 r	2,610
Rubber	42	36
Textiles	206	318
Other[4]	40	9
Total	2,330 r	3,180
Grand total	6,770	8,910

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes ammunition, cable covering, castings, sheet and pipe, and type metal.

[3] Includes fireworks and rubber products.

[4] Includes paper and pigments.

Note: Secondary antimonial lead production was 3,020 metric tons (t) in 2009 and 3,520 t in 2010.

TABLE 4
INDUSTRY STOCKS OF PRIMARY ANTIMONY IN THE UNITED STATES, DECEMBER 31[1]

(Metric tons of antimony content)

Type of material	2009	2010
Metal	155 r	129
Oxide	900 r	1,060
Other[2]	363	372
Total	1,420	1,560

rRevised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes ore and concentrate, residues, and sulfide.

. TABLE 5
U.S. EXPORTS OF ANTIMONY METAL, ALLOYS, AND WASTE AND SCRAP, BY COUNTRY[1]

Country	2009 Gross weight (metric tons)	2009 Value (thousands)	2010 Gross weight (metric tons)	2010 Value (thousands)
Belgium	--	--	38	$434
Canada	85	$433	103	391
China	5	29	3	42
Colombia	3	20	--	--
France	39	503	13	366
Germany	8	25	7	27
India	17	66	81	249
Korea, Republic of	--	--	16	49
Mexico	113	362	82	372
Netherlands	13	40	2	6
Sweden	34	104	--	--
Switzerland	3	59	--	--
Taiwan	12	37	22	71
Trinidad and Tobago	--	--	8	47
United Kingdom	34	215	34	117
Venezuela	15	101	(2)	4
Other	3	9	18	59
Total	385	2,000	427	2,230

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6

U.S. EXPORTS OF ANTIMONY OXIDE, BY COUNTRY[1]

	2009			2010		
Country	Gross weight (metric tons)	Antimony content[2] (metric tons)	Value (thousands)	Gross weight (metric tons)	Antimony content[2] (metric tons)	Value (thousands)
Australia	28	23	$105	20	17	$55
Belgium	17	14	135	16	13	114
Brazil	2	2	21	20	17	118
Canada	218	181	1,210	238	198	1,780
Chile	2	2	11	56	46	159
China	44	37	175	132	110	389
Colombia	20	17	96	81	67	633
Costa Rica	2	2	13	20	17	117
France	14	12	61	25	21	83
Germany	49	41	276	166	138	810
Hong Kong	58	48	150	80	66	208
India	63	52	205	--	--	--
Indonesia	54	45	265	27	22	164
Italy	14	12	47	(3)	(3)	7
Japan	128	106	596	104	86	380
Korea, Republic of	54	45	203	229	190	774
Mexico	993	824	4,950	474	393	3,130
Netherlands	61	51	282	80	66	463
Singapore	2	2	23	76	63	235
South Africa	52	43	172	9	7	40
Spain	4	3	6	--	--	--
Taiwan	34	28	109	95	79	479
Thailand	16	13	61	40	33	108
United Kingdom	119	99	435	538	447	1,620
Venezuela	3	2	12	14	12	122
Other	5 [r]	4 [r]	36 [r]	10	9	42
Total	2,060	1,710	9,660	2,550	2,120	12,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Antimony content is calculated by the U.S. Geological Survey.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF ANTIMONY, BY CLASS AND COUNTRY[1]

Country	2009 Gross weight (metric tons)	2009 Antimony content[2] (metric tons)	2009 Value (thousands)	2010 Gross weight (metric tons)	2010 Antimony content[2] (metric tons)	2010 Value (thousands)
Antimony ore and concentrate:						
Bolivia	121	83	$521	70	49	$332
Canada	(3)	(3)	4	--	--	--
China	62	40	109	20	20	52
Italy	85	43	375	218	112	1,450
Total	268	167	1,010	308	181	1,840
Antimony oxide:						
Belgium	1,860	1,540	9,520	2,240	1,860	16,500
Bolivia	1,940	1,610	8,180	719	597	5,060
Brazil	--	--	--	2	1	13
China	11,200	9,310	43,100	19,100	15,800	107,000
France	456	378	2,850	156	130	1,070
Germany	(3)	(3)	7	4	3	18
Hong Kong	--	--	--	20	17	113
Japan	182	151	1,040	364	302	2,000
Mexico	2,430	2,020	14,700	1,940	1,610	10,600
Netherlands	154	128	1,080	134	111	925
Taiwan	115	95	557	236	196	1,150
Other	(3)	1 [r]	20 [r]	(3)	(3)	29
Total	18,300	15,200	81,000	24,900	20,600	144,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Antimony ore and concentrate content reported by the U.S. Census Bureau. Antimony oxide content is calculated by the U.S. Geological Survey.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8

U.S. IMPORTS FOR CONSUMPTION OF ANTIMONY METAL, BY COUNTRY[1]

Country	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Australia	95	$398	194	$891
Bolivia	58	236	18	90
China	3,040	14,900	4,530	35,600
Hong Kong	--	--	19	202
India	10	82	43	413
Japan	(2)	153	56	163
Mexico	1,170	1,740	363	495
Peru	212	995	--	--
United Kingdom	44	362	50	424
Vietnam	119	590	79	633
Other	(2)	126 [r]	4	158
Total	4,750	19,600	5,360	39,100

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9

ANTIMONY: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, antimony content unless otherwise specified)

Country[3]	2006	2007	2008	2009	2010[e]
Australia[e, 4]	1,600	1,010	1,500	1,000	1,000
Bolivia	5,460	3,881	3,905	2,990 [r]	4,980
Canada[5]	269 [r, 6]	193 [r, 6]	132 [r, 6]	66 [r, 6]	1,000
China[e]	153,000	163,000	166,000	140,000	150,000
Guatemala	--	1,000 [e]	--	--	--
Kyrgyzstan[e]	50	10	10	10	10
Peru, refined[e]	691	590	531	530	530 [p]
Russia, recoverable[e]	3,500	3,500	3,500	3,500	3,000
South Africa[5]	4,362	3,354	3,370	2,800	3,000
Tajikistan[e]	2,000	2,000	2,000	2,000	2,000
Thailand, content of ore and concentrate	1,409	--	--	--	--
Turkey[e]	1,100	1,200	1,300	1,200 [r]	1,500
Total	173,000	180,000	182,000	154,000 [r]	167,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 18, 2011.

[3] In addition to the countries listed, antimony may have been produced in Iran, but information is inadequate to estimate output.

[4] Antimony content of antimony ore and concentrate, lead concentrates, and lead-zinc concentrates.

[5] Antimony content of concentrate.

[6] Reported figure.

ARSENIC

By William E. Brooks

Domestic tables were prepared by Samir Hakim, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, the United States produced no arsenic and relied mainly on Morocco and China, the leading and second ranked import sources, respectively, for arsenic trioxide and on China and Japan, the leading and second ranked import sources, respectively, for arsenic metal. There has been no domestic production of arsenic trioxide nor arsenic metal since 1985 following the closure of the ASARCO Inc. copper smelter in Tacoma, WA. Arsenic trioxide was used mostly for the production of chromated copper arsenate (CCA), a pesticide and preservative used to pressure treat some wood products, and for production of agricultural chemicals; however, its use as a preservative for outdoor domestic wood products, such as decks, was voluntarily discontinued at yearend 2003. Arsenic metal was used for electronics applications and in nonferrous alloys. In 2010, the United States remained the world's leading consumer of arsenic trioxide and arsenic metal.

Legislation and Government Programs

The Safe Drinking Water Act of 1975 mandated that the U.S. Environmental Protection Agency (EPA) identify and regulate drinking water contaminants, such as arsenic, that may have adverse effects on human health. The maximum contaminant level for arsenic was established at 0.05 milligram per liter (mg/L), and in 2001, was revised to 0.01 mg/L.

By yearend 2010, arsenic removal technology, using a variety of methods that included adsorptive media, coagulation/filtration, iron removal, or oxidation/filtration had been tested at locations that included Alvin, TX; Felton, DE; Goshen, IN; Lake Isabella CA; Lead, SD; Nambe Pueblo, NM; Okanogan WA; and Sabin, MN. Reports that discuss the results of these site studies were available at the EPA's arsenic Website (http://www.epa.gov/nrmrl/wswrd/dw/arsenic).

For example, at the Lead, SD, site, an adsorptive media system was evaluated in order to meet the maximum contaminant level of 10 micrograms per liter (μg/L). This project also evaluated the reliability of the arsenic removal system, its operation and maintenance, operator skills, and cost. Total arsenic concentrations in source water ranged from 16.9 to 26.3 μg/L and averaged 21.6 μg/L. The study was for 25 months and was divided into two study periods. After the first study period, arsenic concentrations in the effluent were reduced to 5.8 μg/L, and then circuit revisions were made resulting in arsenic concentration in the effluent being reduced to 0.5 μg/L by the end of the second study period (Wang and others, 2010).

Environmental and Human Health Issues

Arsenic is a naturally occurring element that may be present in drinking water as a result of weathering of arsenic-containing minerals exposed by natural processes or released by mining and smelting; as runoff from arsenic-containing pesticides used in orchards; in wastewater runoff from glass and electronics production; as arsenic released from coal-fired powerplants or from underground coal fires; or from volcanic eruptions. In humans, some of the noncancerous effects of arsenic exposure include blindness, diarrhea, discoloration and thickening of the skin, nausea, stomach pain, and vomiting. Prolonged arsenic exposure has been linked to cancer of the bladder, kidney, liver, lungs, and prostate (Agency for Toxic Substances and Disease Registry, 2007).

Owing to runoff from the Sierra Nevada Mountains, CA, which have high concentrations of natural arsenic, the arsenic concentrations in Mono Lake, CA, are 700 times greater than the EPA considers safe. Research by university, U.S. Geological Survey, and U.S. National Aeronautical and Space Administration scientists indicated that bacteria sampled from those arsenic-laden sediments used arsenic, instead of phosphorus, as a building block for life and for cellular functions. Phosphorus is nearly perfect for building the framework needed for the DNA molecule and is also useful for energy transfer within cells; however, it remained to be established how the bacteria use arsenic as a replacement for phosphorus. Regardless, this research may help redefine what to look for in terms of the chemical architecture necessary to understand extraterrestrial life (Kaufman, 2010; Wolf-Simon and others, 2010).

British scientists reported that the oil spill in the Gulf of Mexico in 2010 increased the levels of arsenic in the world's oceans. Arsenic is normally filtered out of the ocean's waters and combines with sediments; however, oil spills stop the normal process by combining with the sediment, which then leads to an accumulation of arsenic in the water. This results in bioaccumulation of arsenic in the food chain and may eventually impact humans (New York Post, 2010).

Near Anstead, WV, well water and streams were tested for metal content. Tests indicated that antimony, arsenic, barium, lead, and manganese, which may be related to coal-mining and coal occurrences in the area, were at unacceptable levels. However, since some of the water tested came from wells on private property, EPA regulations did not apply. Recommendations for residents that get their drinking water from wells included getting wells tested, the use of bottled water, or get connected to the public water supply (Lannom, 2010).

Electronic waste (e-waste) may contain arsenic, beryllium, cadmium, copper, gold, lead, mercury, and silver that may be recycled. However, the small-scale recovery of the metals may pose an environmental hazard and risk to human health (Schmit, 2008). Vermont solid waste districts took in 725 metric tons (t) of electronic waste in 2008, and the State passed legislation in 2010 addressing disposal of most electronic devices, including cellular telephones, computers, electronic devices, and televisions. The legislation makes disposal of e-waste illegal in landfills as of January 1, 2011 (Metal-Pages, 2010d).

Consumption

Arsenic is one of the components of CCA, a widely used wood preservative used in pressure-treated wood. The major domestic consumers of arsenic, as CCA, include Arch Wood Protection, Inc., Norwalk, CT; Osmose Wood Preserving, Inc., Buffalo, NY; and Viance LLC, Charlotte, NC. In response to concerns about the effects of arsenic exposure on human health, domestic manufacturers of wood preservatives voluntarily reduced their use of CCA at yearend 2003. The phaseout applied to wood used for boardwalks, decks, fencing, gazebos, picnic tables, and play structures. However, wood treated with CCA prior to December 31, 2003, could still be used, and glue-laminated beams, marine timbers, plywood flooring and roofing, and utility poles could still be treated with CCA.

The United States remained the world's leading consumer of arsenic, mainly for the production of CCA. Apparent domestic consumption for arsenic was about 4,820 metric tons (t) in 2010, a slight increase from 4,740 t in 2009. The estimated value of arsenic compounds and metal consumed domestically in 2010 was approximately $4.9 million.

In 2010, slightly more than 50% of the arsenic, as arsenic trioxide, was used in the wood preservative industry for nonresidential use. The remainder of the arsenic trioxide was used in agricultural chemicals (either directly or after conversion to arsenic acid) or in glass manufacturing applications. Arsenic acid also was used in glassmaking as a bubble dispersant or decoloring agent. No data were available on the percentages of arsenic used in these traditional use categories.

Some arsenic may be found as an impurity in copper, and alloys containing arsenic have been used to produce hardened copper tools since ancient times (Petersen, 1970, p. 61). Arsenic metal is used, along with antimony, to harden ammunition, in solders, and in other applications. Grids and posts in lead-acid storage batteries are strengthened by the addition of arsenic metal. Arsenic is one of several metals used as an antifriction additive in babbitt metals (alloys that are used for bearings).

High-purity (99.9999%) arsenic metal is used for gallium-arsenide (GaAs), indium-arsenide (InAs), and indium-gallium-arsenide semiconductors that are widely used in computer, biomedical, communications, electronics, and photovoltaic applications. Arsenic may be used for germanium-arsenide-selenide or GaAs specialty optical materials. Arsenic sulfide is one of several substrate materials that are used for optical thin films and interference coatings for applications in data recording media, optical communications systems, and sensors. A cellular telephone typically contains GaAs in its circuitry, of which the arsenic content is less than 1 milligram; however, since 2007, there are more GaAs components in the newer 3G and 4G cell phones. Based on reported consumption of 40 t of gallium in 2010, U.S. consumption of arsenic metal in GaAs semiconductors was also approximately 40 t in 2010, which was equal to a peak of about 40 t of arsenic metal used in 2000.

Prices

China was the world's leading producer of arsenic trioxide and arsenic metal; however, there was little change in the overall arsenic market, and sales continued to be low through July 2010. Suppliers complained that because of a lack of consumer buying, only a few small transactions took place in early 2010. In July, the price in Beijing, China, for arsenic trioxide (minimum 99%) was $0.51 per kilogram, an increase from the $0.39- to $0.41-per-kilogram price at midyear 2009 (Metal-Pages, 2010c).

In July, the price for 99%-pure arsenic metal was $1,230 per metric ton, a slight decrease from the November 2009 price (Metal-Pages, 2010a). However, by December 2010, the price had risen to approximately $1,500 per metric ton (Metal-Pages, 2010b).

Foreign Trade

In 2010, domestic imports of arsenic compounds were 4,530 t contained arsenic, an overall decrease of approximately 3% compared with the 4,660 t contained arsenic in arsenic compounds imported in 2009. Arsenic trioxide contains 76% arsenic. In 2010, Morocco was the source of 62% of the arsenic trioxide imported into the United States, China was the source of 21%, and Belgium was the source of 16%. Imports of arsenic trioxide into the United States in 2010 from Morocco decreased by 19%; increased from China by 17%; and increased from Belgium by 89%.

In 2010, the United States imported 769 t of arsenic metal, a 75% increase compared with the 438 t of arsenic metal imported in 2009. China was the leading source of arsenic metal in 2010 and provided 639 t of arsenic metal, or 83%; however, this was an increase of 73% compared with the 370 t of arsenic metal that was imported from China in 2009. Arsenic metal was also imported from Japan (16%) and other countries.

Exports of arsenic metal from the United States in 2010 increased to 481 t from 354 t in 2009. Export destinations included Honduras (41%), Morocco (18%), Chile (11%), and Canada (10%). In the Harmonized Tariff Schedule, exported materials are classified only by number and may or may not be inspected so as to confirm the contents of the shipping container. This may have resulted in misclassification of the exported material, and therefore, exports of material classified as arsenic metal may vary from year to year. This classification may also include arsenic-containing "e-waste," such as computers and other electronics destined for reclamation and recycling (Mayo, 2008; Schmit, 2008), transshipped arsenic metal used for production of small-arms ammunition (Agence France-Presse, 2005; Chicago Tribune, The, 2005), and arsenic alloyed with lead or another metal.

World Review

In 2010, commercial-grade arsenic trioxide was recovered from processing of nonferrous ores or concentrates in 11 countries. Reduction of arsenic trioxide to arsenic metal accounted for all world output of commercial-grade (99%-pure) arsenic metal.

In 2010, China produced approximately 25,000 t of arsenic trioxide and remained the world's leading producer followed by Chile (11,000 t), Morocco (8,000 t), and Peru (4,500 t). Arsenic was also produced in China as a byproduct of gold mining from orpiment (As_2S_3) and realgar (AsS), the more common ore minerals of arsenic (Peters and others, 2002, p. 182). Arsenic trioxide was also produced in Mexico at the San Luis Potosi copper smelter.

Arsenic-containing residues and smelter dusts recovered from nonferrous metals plants in several countries may not have been processed to recover commercial-grade arsenic trioxide in 2010 and may have been stockpiled for future treatment. Production data for most countries were estimated and subject to revision.

Outlook

The voluntary decision by the wood preservative industry to eliminate CCA as a wood preservative for certain wood products has led to a decline in U.S. consumption and a decline in arsenic trioxide production in China. The use of alternative wood preservatives and wood alternatives, such as concrete, plastic, or wood composites, will continue to substitute for CCA wood preservatives. Borate-treated wood is resistant to insects and fungal decay, but its use is recommended only for interior or weather-shielded applications. Specific industrial applications, such as marine timber, plywood roofing, and utility poles, are expected to continue to use CCA-treated wood. High-purity arsenic is expected to continue to be used by the electronics industry for GaAs semiconductors. The GaAs slowdown in the first half of 2009 resulted in year-on-year growth for the industry. GaAs technology will be central to supporting the "smartphone" cellular handset. Industry research projected a 5-year average annual growth rate of up to 12% (Anwar, 2010; Higham, 2010). World sources of arsenic, as arsenic trioxide and arsenic metal from nonferrous metal processing, are expected to be sufficient to meet projected needs.

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TABLE 1
ARSENIC SUPPLY-DEMAND RELATIONSHIPS[1]

(Metric tons of arsenic content)

	2006	2007	2008	2009	2010
U.S. supply, imports:					
Metal	1,070	759	376	438	769
Compounds	9,430	7,010	4,810	4,660	4,530
Total	10,500	7,770	5,180	5,100	5,300
Distribution of U.S. supply:					
Exports[2]	3,060	2,490	1,050	354	481
Apparent consumption	7,450	5,280	4,130	4,740	4,820

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Metal only.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF ARSENIC PRODUCTS[1]

	2009		2010	
Class and country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Arsenic trioxide:				
Belgium	514	$297	973	$603
China	1,080	440	1,260	561
Germany	--	--	4	29
Morocco	4,530	1,970	3,690	1,640
Spain	10	36	--	--
Total	6,130	2,740	5,920	2,830
Arsenic acid:				
Indonesia	--	--	20	8
Japan	3	11	(2)	3
Taiwan	--	--	40	32
Total	3	11	60	43
Arsenic sulfide:				
Italy	77	334	--	--
Russia	--	--	13	35
Total	77	334	13	35
Arsenic metal:				
China	370	993	639	1,020
Germany	1	276	1	297
Japan	67	613	125	1,100
Korea, Republic of	--	--	4	11
United Kingdom	(2)	5	(2)	7
Total	438	1,890	769	2,440

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3

ARSENIC TRIOXIDE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Metric tons)

Country[4]	2006	2007	2008	2009	2010
Belgium	1,000	1,000	1,000	1,000	1,000
Bolivia	120 [r, 5]	--	74 [5]	115 [r, 5]	155 [6]
Canada	-- [r]	-- [r]	-- [r]	-- [r]	--
Chile	11,700	11,400	10,000	11,000	11,000
China	30,000	25,000	25,000	25,000	25,000
Iran	100	100	100	100	100
Japan	40	40	40	40	40
Kazakhstan	1,500	1,500	1,500	1,500	1,500
Mexico	1,595 [5]	1,600	513	500	--
Morocco	8,900 [5]	8,950 [5]	8,800	8,500	8,000
Peru[7]	4,399 [5]	4,321 [5]	4,822 [5]	4,850	4,500 [e]
Portugal	15	15	15	15	15
Russia	1,500	1,500	1,500	1,500	1,500
Total	60,900 [r]	55,400 [r]	53,400 [r]	54,100 [r]	52,800

[r] Revised. -- Zero.

[1] Including calculated arsenic trioxide equivalent of output of elemental arsenic compounds other than arsenic trioxide where inclusion of such materials would not duplicate reported arsenic trioxide production.

[2] World totals and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[3] Table includes data available through April 20, 2011.

[4] Austria, Hungary, the Republic of Korea, Serbia and Montenegro, South Africa, Ukraine, the United Kingdom, and Zimbabwe have produced arsenic and (or) arsenic compounds in previous years, but information is inadequate to make estimates of output levels, if any.

[5] Reported figure.

[6] Estimated exports of arsenic trioxide reported by Bolivia's Ministry of Mines and Metallurgy (in 2009).

[7] Output of Empresa Minera del Centro del Perú (Centromín Perú) as reported by the Ministerio de Energía y Minas.

ASBESTOS

By Robert L. Virta

Domestic survey tables were prepared by Richard H. Kraft, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Asbestos has not been mined in the United States since 2002, and imports, 99% from Canada, satisfied the needs of domestic consumers. U.S. apparent consumption was 1,040 metric tons (t) in 2010, an increase from 869 t in 2009. World production was 2.01 million metric tons (Mt) in 2010, a decrease from 2.13 Mt in 2009.

Consumption

U.S. consumption of asbestos was 1,040 t in 2010, an increase from 869 t in 2009 (table 1). Roofing products accounted for 58% of U.S. consumption; diaphragms for the chloralkali industry, 35%; coating and compounds, 2%; and other uses, 5%. Chrysotile was the only type of asbestos used in the United States in 2010, 64% of which was grade 7, 20% was grade 5, 15% was grade 4, and 1% was unspecified (table 2).

Prices

The average free alongside ship (f.a.s.) unit value of unmanufactured asbestos fiber exports was $708 per metric ton in 2010, a decrease from $1,169 per ton in 2009. The average U.S. customs unit value for all grades of imported asbestos was $786 per ton in 2010, unchanged from that of 2009. The average value of imported crude chrysotile, all from Canada, was $872 per ton in 2010, a large increase from $203 per ton in 2009. This increase may have resulted from additional processing of the crude chrysotile or higher prices for spot, rather than long-term purchases. The average unit value for imports of milled, grade 4 chrysotile was $1,858 per ton in 2010, a slight increase from $1,843 per ton in 2009.

Foreign Trade

The following section summarizes significant trade statistics on asbestos and products manufactured using asbestos. Detailed trade statistics, by country and individual U.S. port districts, are available from the International Trade Commission's Interactive Tariff and Trade Dataweb Web site (U.S. International Trade Commission, undated).

In 2010, U.S. exports of asbestos fiber were 171 t with an f.a.s. value of $121,000, an increase in tonnage from 59 t valued at $69,000 in 2009 (tables 3, 4). Asbestos has not been produced in the United States since 2002; thus, reported exports probably consisted of reexports of imported fiber or improperly classified products. The United States exported and reexported $27 million of asbestos products in 2010, an increase from $24.5 million in 2009. Canada was the leading destination, followed by the United Kingdom, Mexico, the Republic of Korea, and China. These five countries accounted for 64% of the value of asbestos products exported and reexported from the United States in 2010 (table 3). The United Kingdom banned the use of asbestos in 1999, so imports from the United States probably were reexported from the United Kingdom or were nonasbestos products misclassified as asbestos products. The same applies to several other countries listed in table 3 that have banned the use of asbestos or asbestos products.

Friction products, including brake linings, clutch linings, and disk pads, accounted for 56% of the value of manufactured products exported in 2010 (table 4). Because no asbestos brake components under Harmonized Tariff Schedule of the United States (HTS) code 6813.20 or asbestos-cement products under HTS code 6811.40 were manufactured in the United States, shipments under these two HTS code categories probably represent reexports of asbestos products and (or) exports of products incorrectly classified under these HTS codes.

In 2010, the United States imported 1,040 t of asbestos valued at $821,000. Canada supplied 99% of the tonnage; the remainder was imported from Brazil (table 5). Most likely, only chrysotile was imported into the United States in 2010. Based on the import source, asbestos listed under "other, unspecified asbestos type" in table 5 probably represented chrysotile.

The United States also imported $5.78 million of products with a basis of asbestos and products with a basis of asbestos and magnesium carbonate, a significant decrease from $13.3 million in 2009 (U.S. International Trade Commission, undated). Some nonasbestos products probably are included under the asbestos HTS codes based on reported asbestos imports from countries that have banned asbestos use (table 6).

World Review

World production of asbestos was estimated to be 2.01 Mt in 2010, a decrease from 2.13 Mt in 2009. It was estimated that Russia was the leading producer of asbestos, followed by China, Brazil, Kazakhstan, and Canada. These five countries accounted for 99% of the world production (table 7).

Brazil.—Eternit S.A. indicated that its chrysotile mine operated at full capacity and its fiber cement plants operated at greater than 90% capacity. In 2010, chrysotile sales, including some sales from stocks, were 306,000 t, 5% greater than in 2009. Fiber cement sales were 827,000 t in 2010, 13% greater than in 2009. Eternit also increased the capacity of its fiber cement plant to 1 Mt from 850,000 t (Eternit S.A., 2011, p. 1, 3).

Canada.—Shareholders of Mine Jeffrey Inc., in Asbestos, Quebec, approved the purchase of the privately held company by an international consortium. However, the purchase was conditional on the Quebec Government guaranteeing a $56 million bank loan. At yearend, no decision had been made concerning the loan. The purchase of the mine would enable the company to complete the underground portion of its mine and eventually increase production to 250,000 metric tons per year (t/yr) from 15,000 t/yr (Canadian Mining Journal, 2010; Industrial Minerals, 2010).

Outlook

U.S. consumption, although increasing from that of 2009, remained lower than consumption for the prior 100 years. U.S. asbestos consumption is likely to decline further as the use of products and technologies that do not require asbestos continue to increase. World production remained nearly 2.01 Mt because of continued demand for asbestos products in many regions of the world.

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TABLE 1

SALIENT ASBESTOS STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Exports and reexports:[2, 3]						
Unmanufactured, value	thousands	$866	$421	$345	$69	$121
Asbestos products, value	do.	$443,000	$29,200	$33,200	$24,500	$27,000
Imports for consumption, unmanufactured:						
Quantity	metric tons	2,230	1,730	1,460	869	1,040
Value[4]	thousands	$1,000	$819	$1,090	$684	$821
Consumption, apparent	metric tons	2,230	1,730	1,460	869	1,040
World, production	do.	2,150,000 r	2,250,000 r	2,110,000 r	2,130,000 r	2,010,000

do. Ditto. rRevised.

[1] Data are rounded to no more than three significant digits.

[2] Free alongside ship value; includes exports of crudes, fibers, stucco, sand, and refuse.

[3] Export data for asbestos products prior to 2007 also included nonasbestos products.

[4] U.S. customs declared value.

TABLE 2
U.S. ASBESTOS CONSUMPTION BY END USE, GRADE, AND TYPE[1, 2]

(Metric tons)

	Chrysotile					
End use	Grade 3	Grade 4	Grade 5	Grade 7	Unspecified grade	Total
2009	2	65	152	576	74	869
2010:						
Coatings and compounds[3]	--	--	--	17	--	17
Chlorine industry	--	157	208	--	--	365
Plastics	--	--	--	7	--	7
Roofing products	--	--	--	603	--	603
Other	--	--	--	38	13	51
Total	--	157	208	666	13	1,040

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Estimated distribution based upon data provided by the Chrysotile Institute, Montreal, Quebec, Canada.

[3] Most of the asbestos reported under "Coating and compounds" probably was used in roofing products.

TABLE 3
VALUE OF U.S. EXPORTS AND REEXPORTS OF ASBESTOS FIBERS AND ASBESTOS–BASED PRODUCTS[1, 2, 3]

(Thousand dollars)

	2009			2010		
Country	Unmanufactured fiber[4]	Manufactured products	Total	Unmanufactured fiber[4]	Manufactured products	Total
Australia	--	194	194	--	203	203
Brazil	--	165	165	--	58	58
Canada	--	5,560	5,560	--	5,460	5,460
China	--	1,610	1,610	--	1,210	1,210
France	--	218	218	--	49	49
Germany	--	269	269	--	242	242
Italy	--	72	72	--	253	253
Japan	--	477	477	--	175	175
Korea, Republic of	--	1,520	1,520	--	1,600	1,600
Mexico	--	4,430	4,430	83	3,880	3,970
Netherlands	--	9	9	--	5	5
United Kingdom	--	3,240	3,240	--	5,100	5,100
Venezuela	--	294	294	--	119	119
Other	69	6,450	6,520	38	8,620	8,660
Total	69	24,500	24,600	121	27,000	27,100

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship value.

[3] Data may include some nonasbestos products based on destination countries that have banned the use of asbestos.

[4] Includes exports of crudes, fibers, stucco, sand, and refuse. May also include nonasbestos materials.

Source: U.S. Census Bureau.

TABLE 4
U.S. EXPORTS AND REEXPORTS OF ASBESTOS AND ASBESTOS–BASED PRODUCTS[1]

	2009		2010	
	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Unmanufactured, asbestos[3]	59	$69	171	$121
Manufactured:				
Cement products[4]	NA	427	NA	236
Friction products[5]	NA	13,500	NA	15,000
Gaskets, packing and seals	NA	1,270	NA	1,510
Paper and millboard	NA	317	NA	50
Other articles[6]	NA	9,040	NA	10,200
Total	NA	24,500	NA	27,000

NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship value.

[3] Includes crudes, fibers, stucco, sand, and refuse. May also include nonasbestos materials.

[4] May include reexports and also cellulose fiber panel, sheet, tile, and tube cement products because asbestos-cement products are not manufactured in the United States.

[5] May include some nonasbestos brake and clutch shipments.

[6] May also include some nonasbestos materials.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF ASBESTOS FIBERS, BY TYPE AND ORIGIN[1]

	Canada		Brazil		Zimbabwe		Total	
Type	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
2009:								
Chrysotile:								
Crude	40	$8	--	--	--	--	40	$8
Milled, grade 4	106	178	7	$19	14	$38	127	234
All other	332	128	53	147	--	--	385	275
Other, unspecified asbestos type	317	167	--	--	--	--	317	167
Total	795	480	60	166	14	38	869	684
2010:								
Chrysotile:								
Crude	234	204	--	--	--	--	234	204
Milled, grade 4	177	307	13	46	--	--	190	353
All other	374	145	--	--	--	--	374	145
Other, unspecified asbestos type	246	119	--	--	--	--	246	119
Total	1,030	775	13	46	--	--	1,040	821

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] U.S. customs declared value.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS OF PRODUCTS WITH BASIS OF ASBESTOS IN 2010

HTS[1] code	Category	Quantity (metric tons)	Value[2]	Major sources[3]	Percentage of category total[4]
2524.00.00.00	Asbestos	1,040	$821,000	Canada	99% of weight.
6811.40.00.00	Asbestos-cement products	3,080	380,000	do.	91% of weight.
6812.80.90.00	Other, fabricated crocidolite fibers; clothing[5]	(6)	3,400	Germany[7]	Do.
6812.91.10.00	Footwear, fabricated asbestos fibers; clothing[8]	(6)	5,760	Pakistan	Do.
6812.91.90.00	Other, fabricated asbestos fibers; clothing[8]	(6)	5,250	China	Do.
6812.92.00.00	Felt, millboard, and paper[8]	NA	45,400	India	80% of value.
6812.93.00.00	Compressed asbestos fiber jointing[8]	NA	437,000	Mexico	97% of value.
6812.99.00.01	Other, miscellaneous[8]	37	1,000,000	Austria[7], Mexico	100% of weight.
6812.99.00.02	Yarn and thread[8]	3	67,300	China, Mexico	Do.
6812.99.00.04	Woven or knitted fabric[8]	6	65,300	China	99% of weight.
6812.99.00.20	Gaskets, packing, and seals[8]	54	318,000	do.	94% of weight.
6812.99.00.25	Building materials	NA	27,000	Canada	100% of weight.
6812.99.00.55	Other, fabricated asbestos fiber[8]	NA	86,500	South Africa	63% of value.
6813.20.00.10	Brake lining and pads, civil aircraft[8]	NA	295,000	Brazil	53% of value.
6813.20.00.15	Brake lining and pads, other	NA	2,160,000	China, Japan[7]	67% of value.
6813.20.00.25	Other, friction materials	NA	59,700	Canada, Bolivia	82% of value.

Do., do. Ditto. NA Not available.

[1] Harmonized Tariff Schedule of the United States.

[2] U.S. customs declared value.

[3] Countries are listed in decreasing order.

[4] Percentage contribution of total imports by major import sources, by weight or value.

[5] Products likely to have been inaccurately classified and products probably do not contain crocidolite.

[6] Less than ½ unit.

[7] Source likely a supplier of nonasbestos products only.

[8] Mixtures with basis of asbestos or with a basis of asbestos and magnesium carbonate.

Source: U.S. Census Bureau.

TABLE 7
ASBESTOS: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010
Argentina	299	282	298	290	300
Brazil, fiber	227,000	254,000	288,000	288,000	270,000 [e]
Canada[e]	200,000	180,000 [4]	160,000	150,000	100,000
China[e]	360,000	390,000	380,000	440,000 [r]	400,000
India[e]	20,000	21,000	20,000	19,000	20,000
Iran[e]	1,300	--	--	--	--
Kazakhstan	315,000	293,000	230,000	230,000 [e]	214,000
Russia[e]	925,000	1,030,000 [4]	1,020,000 [4]	1,000,000	1,000,000
Serbia	4,500	--	--	--	--
Zimbabwe	100,000 [r]	84,500 [r]	11,500 [r]	4,970 [r]	1,000 [e]
Total	2,150,000 [r]	2,250,000 [r]	2,110,000 [r]	2,130,000 [r]	2,010,000

[e] Estimated. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Marketable fiber production. Table includes data available through April 20, 2011.

[3] In addition to the countries listed, Afghanistan, North Korea, Romania, and Slovakia also produce asbestos, but output is not officially reported, and available general information is inadequate for the formulation of reliable estimates of output levels.

[4] Reported figure.

BARITE

By M. Michael Miller

Domestic survey data and tables were prepared by Raymond I. Eldridge III, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, primary barite production (sold or used by producers) totaled 662,000 metric tons (t) valued at $37.2 million, and apparent consumption was 2.66 million metric tons (Mt). Imports were 2.11 Mt and exports were 109,000 t.

Barite is the mineralogical name for barium sulfate. In commerce, the mineral is sometimes referred to as barytes. In this report, the term primary barite refers to the first marketable product, which includes crude barite that usually has undergone simple beneficiation methods, such as jigging, tabling, washing, or more complex methods, such as flotation, heavy-media separation, and magnetic separation. Most barite ore requires some upgrading to minimum purity or density levels.

Production

Domestic production and sales data for barite were derived from voluntary responses to the U.S. Geological Survey (USGS) canvass of 7 mines and 26 grinding plants. The USGS received responses from 3 mines and 19 grinding mills, representing 71% of the quantity of ground barite sold. Estimates were made using company production estimates, prior year data, and other industry data. Seven mines were included in the survey—five were producing and two were idle.

Of the canvassed producing mines, four were in Nevada, and one was in Georgia; the idle mines were in Nevada. There were 23 grinding plants operating at the end of the reporting year. Most Nevada barite ore was ground at nearby company-owned grinding plants in Nevada, but the ore from NOV Minerals LP was shipped out of State to its grinding mill in Evanston, WY. Some run-of-mine ore was shipped to Canada for grinding. In 2010, very little, if any, crude barite was shipped to plants on the U.S. Gulf Coast for grinding. This practice has become uncommon in recent years because the cost of transport made Nevada barite uncompetitive with imported barite. Although import prices for barite from China have increased substantially in the past few years, shipments of barite to the Gulf Coast have remained rare. Demand in the Western United States and Western Canada was so strong in recent years that Nevada barite producers were able to sell all their production to western customers.

Crude barite production was 662,000 t in 2010, an increase of nearly 73% compared with that of 2009. The value of domestic production was $37.2 million, an increase of 87%. The bulk of mine production was from Nevada, with a small amount from Georgia. The increase in Nevada's mine production was the result of increased oil and gas drilling driven by higher oil and gas prices.

In 2010, there were four active barite mines in Nevada—Big Ledge Mine (NOV Minerals) and Rossi Mine (Halliburton Energy Services-Baroid) in Elko County, and Argenta Mine (Baker Hughes Drilling Fluids) and Greystone Mine (M-I L.L.C. operating as M-I SWACO) in Lander County. In addition to these Nevada operations, there was one small barite producer in Georgia—New Riverside Ochre Co., Inc.

In 2010, the leading companies that mined and ground barite in the United States were also major oil service companies, which included Baker Hughes Drilling Fluids (a division of Baker Hughes Inc.), Baroid Fluid Services (the drilling fluids and industrial barite subsidiary of Halliburton Energy Services, Inc.), M-I SWACO (a subsidiary of Schlumberger Ltd.), and National Oilwell Varco (NOV). These four companies operated barite mines with associated beneficiation mills and grinding plants in Nevada (or in the case of NOV in Wyoming) and also operated grinding plants in Louisiana and Texas.

At yearend 2010, there were 14 grinding operations on the coast of the Gulf of Mexico (6 in Louisiana and 8 in Texas) that produced barite to American Petroleum Institute (API) specifications. These stand-alone grinding plants primarily processed crude barite imported from China and India that was ground to API specifications for the oil and gas drilling market. Baker Hughes had single plants in Morgan City, LA, and Corpus Christi, TX. Baroid (Halliburton) had two plants in Louisiana at Lake Charles and Larose, and a single plant in Corpus Christi, TX. In 2010, Halliburton completed construction of a new barite grinding mill in Larose, LA. The new grinding mill replaced the company's New Orleans grinding mill, which was shut down when the new plant came online late in the year (Sandy Champagne, oral commun., July 20, 2011). The new plant in Lafourche Parish was designed to allow for easy transport of barite to Halliburton's wharf facilities at Port Fourchon that support offshore oil drilling operations in the Gulf of Mexico (Schmidt, 2009). M-I SWACO (M-I LLC) operated single mills in Amelia, LA, Brownsville, TX, and Galveston, TX. The Brownsville mill was acquired from U.S. Clay LP in 2010. National Oilwell Varco operated a barite grinding plant in Houma, LA (formerly Ambar Lone Star Fluids Services, LLP). National Oilwell Varco acquired Ambar in early in 2010 (National Oilwell Varco Inc., 2010) .

In addition to the barite mining companies, there were a number of other companies that operated grinding mills primarily designed to process imported crude barite. These included Excalibar Minerals Inc. (a division of Newpark Resources, Inc. of Houston), a major barite importer and grinder with one mill in New Iberia, LA, and two mills in Texas at Corpus Christi and Houston. These mills primarily supplied barite to the oil and gas drilling market. The company also operated a grinding plant in Tennessee, which mostly served nondrilling markets. There were two other companies near the Gulf of Mexico that received imported barite by ship through ports in Louisiana and Texas—CIMBAR Performance Minerals, Inc. (Cartersville, GA) in Houston, TX, and Milwhite, Inc.

(a subsidiary of Mexico's Control MINAR, S.A. de C.V.) in Brownsville, TX.

Grinding plants that produced commercial filler-grade barite or chemical-grade barite were located primarily in the Southeast, Midwest, and Texas. Five companies reported sales of barite for nondrilling uses, and by far the leading producer was CIMBAR, which produced most of its nondrilling barite at its three grinding mills in Georgia, Indiana, and Missouri. CIMBAR's second Georgia plant (Cartersville) was idle in 2010.

Consumption

In April 2010, the explosion of the Deepwater Horizon drilling rig and subsea blowout of the Macondo oil well in the Gulf of Mexico resulted in the largest offshore oil spill in U.S. history. A 6-month moratorium on deepwater drilling was declared by the Government in late May and lifted in October after the U.S. Department of the Interior introduced new safety standards for operators drilling in water depths greater than 152 meters (m) (500 feet) (U.S. Department of the Interior, 2010). The drilling moratorium and more stringent regulatory reviews of deep-water drilling applications reduced offshore drilling operations in the Gulf of Mexico, which resulted in a decrease in barite sales and consumption in the Gulf of Mexico. In mid-April (before the moratorium), there were 55 drilling rigs operating in the Gulf of Mexico, but by mid-July the number had dropped to 12 (Baker Hughes Inc., 2011). Deepwater wells require much larger amounts of barite than most onshore wells because of deeper drilling depths and higher pressures, so this small decrease in operating rigs had a significant impact on Gulf of Mexico barite sales. Some experts estimate it could take 2 years for oil and gas production in the Gulf of Mexico to return to prespill levels.

In 2010, apparent consumption of barite increased by 51% to 2.66 Mt compared with that in 2009 (table 1). Ground barite sales increased by about 24% to 2.57 Mt in 2010 from 2.08 Mt in 2009. In 2010, sales by grinding plants in Louisiana were essentially unchanged at 915,000 t, grinding plant sales in Texas increased by 59% to 907,000 t, while sales by plants in all other States increased by nearly 27% to 748,000 t (table 2). About 2.44 Mt, or 95%, of barite sales from domestic crushers and grinders was for petroleum well-drilling markets, and the remaining 5% was for industrial end uses (table 3).

The leading application for barite is as a weighting agent in natural gas and oil field drilling muds to suppress high formation pressures and prevent blowouts. As a well is drilled, the bit passes through various formations, each with different characteristics. The deeper the hole, the more barite is needed as a percentage of the total mud mix. An additional benefit of barite is that it does not interfere with magnetic measurements taken in the borehole, either during logging-while-drilling or in separate drill hole logging.

Barite used for drilling petroleum wells can be black, blue, brown, buff, or gray depending on the ore body. Most barite needs to be ground to a small uniform size before it is used as a weighting agent in petroleum well-drilling mud based on specifications set by the API or the former Oil Companies' Materials Association.

The most important characteristic of barite used in drilling mud is its specific gravity (SG), and until 2010 the API specification called for a minimum specific gravity of 4.2. In 2008, the API began examining a proposal to lower the barite specific gravity specification to 4.1. In February 2010, the API issued a new edition of API Specification 13A, Specification for Drilling Fluids Materials (effective date, August 1, 2010). This new edition of Specification 13A added specifications for 4.1 specific gravity barite, but also retained specifications for 4.2 specific gravity barite. Other barite specifications remain unchanged from the previous standard and are the same for 4.1 and 4.2 specific gravity barite. They require that the barite be finely ground so that at least 97% of the material, by weight, can pass through a 200-mesh (Tyler) [75-micrometer (µm)] screen, and no more than 30%, by weight, can be less than 6 µm, effective diameter, which is measured using sedimentation techniques. Lastly, the ground barite may contain a maximum of no more than 250 milligrams per kilogram of water-soluble alkaline earth metals as calcium (American Petroleum Institute, 2010, p. 13–23, 83–96). Common impurities in drilling-grade barite include quartz, chert, dolomite, siderite, and metallic oxide and sulfide compounds. These are normally insoluble, and as a result, standards limiting their concentrations have not been developed. In addition, the API standard does not address heavy-metal impurities, but barite derived from base-metal deposits may contain heavy metals such as cadmium and mercury and discharges of these may be regulated under environmental law. For example, U.S. environmental regulations pertaining to offshore drilling allow drilling waste discharges containing barite only if the barite contains less than 3 parts per million cadmium and 1 part per million mercury (Drilling Waste Management Information System, undated).

The idea of using 4.1 specific gravity barite was put forth in late 2006, and since then it has become widely adopted in the Western United States. Offshore drillers continue to use 4.2 specific gravity barite as do onshore customers in other parts of the country that rely on imported barite.

With the U.S. economy recovering in 2010, energy demand increased and this resulted in higher oil and gas prices compared with their lows in 2009. Increased energy demand and higher energy prices were reflected in 2010 by the increase in domestic oil and gas drilling. Oil prices (U.S. spot price) increased by about 28% compared with those of 2009. In 2010, the monthly average was about $79 per barrel compared with an average of nearly $62 per barrel in 2009 (U.S. Energy Information Administration, 2011a). The U.S. monthly average natural gas price (wellhead) was $3.67 per thousand cubic feet in 2009 but increased to $4.16 per thousand cubic feet in 2010. This was, however, still significantly below the 2008 average of $7.97 per thousand cubic feet (U.S. Energy Information Administration, 2011b).

The rebound in oil and gas prices in 2010 encouraged increased exploration drilling in the United States. The weekly U.S. drill rig count in 2010 began the year at 1,220, increased rapidly during the winter and spring to 1,535, decreased slightly owing to the deepwater drilling moratorium, but overall continued to increase and finished the year at 1,694. This number approached the 2008 yearend count of 1,721, but it was still significantly below the peak of 2,031 reached in late summer 2008. Much of the rig count increase was in oil exploration, which accounted for 347 (or 73%) of the 474 additional drill rigs operating at the end of 2010. The percentage of drill rigs exploring for oil accounted for 45% of the total at yearend 2010, up from 35% the previous year. Much of the increased oil exploration activity was in the Williston Basin in northeastern Montana and northwestern North Dakota and in the Permian Basin of West Texas (Baker Hughes Inc., 2011).

In 2010, sales of domestic and imported barite for industrial uses increased by 11% to 131,000 t (table 3). Industrial end uses such as barium chemicals (the largest by volume is barium carbonate), filler in paint and plastics, and powder coatings all require the barite to be ground to a small uniform size. The size depends on the use, but for paint- and plastic-grade material, it averages about 2 to 3 µm. Barite-containing materials that are used for sound reduction in engine compartments are gaining market share among automotive manufacturers. Barite also is used in the base coat of automobile finishes for smoothness and corrosion resistance and continues to be used in friction products for automobiles and trucks.

Barite used as an aggregate in "heavy" cement or radiation-shielding cement is crushed and screened to sizes ranging from 4.75 millimeters (0.187 inches) to 3.75 centimeters (1.5 inches) for the coarse grade. New Riverside Ochre (Cartersville, GA) is the leading supplier of barite aggregate.

Foreign Trade

Barite exports in 2010 were 109,000 t, which was an increase of about 60,000 t compared with those of 2009. Most exports went to Canada (90%) in the form of crude barite, which was ground in Canada and then consumed for oil and gas drilling in the western provinces of Alberta, British Columbia, and Saskatchewan. The bulk of the remaining exports went to Mexico (5%) and Venezuela (2%) (table 4).

Assignment of the correct harmonized tariff schedule (HTS) number by importers is sometimes problematic. As a result, in prior years, adjustments were made in an attempt to classify imports of crude natural barite, ground barite, and other sulfates of barium by type and use. These adjustments involved separating, by unit value, imports intended for use in drilling muds (crude and ground barite), and all other uses (other sulfates of barium). Beginning in 2008 this practice was discontinued, and the data shown in table 5 for 2009 and 2010 are as reported by the U.S. Census Bureau.

Combined imports of barite (crude and ground) totaled 2.09 Mt, an increase of 47% compared with those of 2009. China accounted for 92% of the total, with India (4%) and Morocco (3%) making up most of the rest. Imports for the several forms of barite reported under the HTS nomenclature "Other sulfates of barium" were 14,700 t, which represents an increase of 39% compared with those of 2009 (table 5).

There is a tariff on U.S. imports of crude barite of $1.25 per metric ton, but there is no tariff on imports of ground barite. As a result, some of the major importers of crude barite have applied for and received foreign trade zone (FTZ) status for their grinding mills in the United States. In 2007, M-I SWACO received FTZ approvals for the company's grinding plants in Amelia, LA, and Galveston, TX. In 2008, Baker Hughes received FTZ approvals for its grinding plants in Morgan City, LA, and Corpus Christi, TX. Also in 2008, Halliburton received FTZ approvals for its grinding plants in New Orleans, LA; Westlake, LA; and Corpus Christi, TX. In January 2010, Excalibar Minerals received FTZ approval for its grinding plant in Corpus Christi, TX. FTZ status means that the ground barite produced by these mills will be reported as imports for consumption and not crude barite received from foreign suppliers (U.S. Department of Commerce, Import Administration, 2011).

Transportation

In recent years, about 80% of U.S. barite consumption has been supplied by imports (primarily from China). Most barite imports are shipped in handymax-size bulk carriers (typically 35,000- to 60,000-t deadweight tonnage). After being ground to API specifications, barite is transferred directly to containers on barges docked in canals, lakes, and rivers near the grinding mills for bulk delivery to offshore drilling platforms. These near-shore barite staging locations also are convenient to the clusters of onshore areas with significant petroleum production in the Petroleum Administration for Defense (PAD) District 3. The PAD districts were World War II divisions of the oil-producing areas of the United States; these designations continue to be used.

Prices

The average sales value for primary barite from mines and their associated beneficiation plants in the United States increased to about $56 per metric ton, an increase of about $4 per metric ton compared with that of 2009 (table 1). Compared with those of 2009, the average sales value for barite ground in Louisiana was essentially unchanged at about $144 per ton, while the sales value for drilling-grade barite ground in Texas decreased slightly to about $165 per ton. The average value for all grades ground in Texas was essentially unchanged at $169 per ton, while the sales value of barite ground in other States increased to about $142 per ton (table 2). Barite for barium chemicals, filler and extender, and glass decreased by 3% to $334 per ton for 2010 compared with that of 2009 (table 3).

The December 2010 United States published import prices for barite from China, API grade, lump, including cost, insurance, and freight, U.S. Gulf Coast, were in a range of $100 to $108 per ton compared with $94 to $108 per ton in December 2009. The price for Indian barite increased to a range of $107 to $112 per ton compared with $97 to $99 per ton in December 2009. The price of chemical-grade barite from China increased from $92 to $114 per ton in December 2009 to a range of $138 to $145 per ton in December 2010 (Industrial Minerals, 2009; 2010).

World Review

China.—Weather conditions in China (drought in the winter and early spring and flooding in the summer and fall) hampered production and shipment of barite during 2010. Much of China's barite resources are in the Provinces of Fujian, Guangdong, Guangxi, Guizhou, and Hunan in southern China, which was the region hit hardest by the adverse weather (Russell, 2010). In addition to weather problems, some small producers in Guangxi Province ceased production owing to recently introduced reclamation bond requirements. These permitting requirements, wage increases to miners, and higher fuel prices resulted in higher barite prices, free on board China, which increased throughout the year (Newcaster, 2011). In 2010, China's barite exports were 2.57 Mt, an increase of 800,000 t compared with those of 2009, but still 1.27 Mt less than those of 2008.

India.—India, the world's second leading barite producer, experienced weather-related problems in its barite mining industry as its major barite mine in Andhra Pradesh was flooded by late summer monsoon rains. The lower part of the mine that produced higher quality 4.2 specific gravity product was flooded (Russell, 2010).

Vietnam.—Vietnam's Institute of Geology and Mineral Resources has identified and assessed more than 20 deposits and occurrences of barites with total reserves of 6.2 Mt. Vietnam's primary barite resources are located in three areas in the northern part of the country near the borders with China and Laos and near the coast of the Bac Bo Gulf (Gulf of Tonkin) in North Trung Bo. In 2010, most production was from the Ao Sen deposit in the northeast Bac Bo region, Tuyen Quang Province, which has the capacity to produce about 80,000 metric tons per year (t/yr). Vietnam has developed plans to expand its barite mining industry during the next 15 years, with a target production of 300,000 to 350,000 t/yr (Phuong, 2011).

Outlook

Domestic exploration is expected to continue in response to long-term U.S. demand for oil and gas. The global recession of 2008–09 resulted in dramatic decreases in energy consumption and associated fuel prices. The U.S. economic recovery has been slow and growth in domestic energy consumption has lagged as a result. In recent years, the majority of drill rigs operating in the United States have been exploring for natural gas because the United States has large natural gas resources compared with oil resources. Natural gas production has been increasing faster than consumption, putting downward pressure on natural gas prices—which increased from the lows reached in 2009 but were still significantly below prices reported for 2003–08. Data indicate that dry natural gas production in the first 5 months of 2011 was up 6.0% compared with the same period in 2010. However, natural gas consumption was up only 2.0% during the same time period (U.S. Energy Information Administration, undated). Low natural gas prices may slow exploration activities, especially in areas where the drilling targets are deep and drilling costs are high. For example, the Haynesville Shale located mostly in northern Louisiana lies at a depth of about 3,000 m (10,000 feet).

The 2011 drill rig count through mid-August had risen to 1,974 after beginning the year at 1,694. This increase in exploration activities indicates increased consumption of barite. If the economy continues to stagnate or falls into another recession, energy consumption may fall and with it energy prices resulting in less oil and gas exploration and a decrease in barite consumption.

In the future, natural gas's share of U.S. power generation is likely to increase because of relatively low natural gas prices and the prospect of stricter environmental controls on powerplant emissions. These conditions may result in power companies deferring coal-fired powerplants and building cleaner gas-fired plants in their place. Increased natural gas use may be bolstered by recent increases in the Nation's estimated gas reserves, which reached the highest level since 1971. In 2009, driven by shale gas development, U.S. gas reserves increased to 284 trillion cubic feet. According to the U.S. Energy Information Administration, Louisiana, Arkansas, Texas, Oklahoma, and Pennsylvania were the leading States in adding new proved reserves of natural gas during 2009. Much of this increase in gas reserves is the result of new and advanced exploration, well drilling, and well completion technologies, which allows recovery of natural gas from active and newly developing shale-gas fields (U.S. Energy Information Administration, 2010). A switch from coal to natural gas in new powerplants would likely provide a boost to domestic drilling and increase the demand for barite.

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TABLE 1

SALIENT BARITE STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2006	2007	2008	2009	2010
United States:					
Barite, primary:					
Sold or used by producers:					
Quantity	589	455	648	383	662
Value	23,500	20,600	30,900	19,900	37,200
Exports:					
Quantity	72	15	62	49	109
Value	12,100	6,300	10,500	10,200	17,800
Imports for consumption:[2]					
Quantity	2,550	2,600	2,620	1,430	2,110
Value	160,000	193,000	208,000	129,000	196,000
Consumption, apparent[3]	3,070	3,040	3,210	1,770	2,660
Crushed and ground, sold or used by processors:[4]					
Quantity	3,040	2,980	2,840	2,080	2,570
Value	289,000	308,000	317,000	307,000	391,000
World, production	7,910 r	7,790 r	8,570 r	6,430 r	7,850 e

e Estimated. r Revised

[1] Data are rounded to no more than three significant digits.

[2] Includes crude, ground, and other barite imports.

[3] Sold or used plus imports minus exports.

[4] Includes imports.

TABLE 2

CRUSHED AND GROUND BARITE SOLD OR USED BY PROCESSORS IN THE UNITED STATES, BY STATE[1, 2]

	2009			2010		
State	Number of plants	Quantity (thousand metric tons)	Value (thousands)	Number of plants	Quantity (thousand metric tons)	Value (thousands)
Louisiana	6	921	$134,000	7	915	$132,000
Texas	8	569	96,000	8	907	153,000
Other[3]	12	591	77,100	11	748	106,000
Total	26	2,080	307,000	26	2,570	391,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes imports.

[3] Includes Georgia, Illinois, Indiana, Missouri, Nevada, Tennessee, and Wyoming.

TABLE 3
CRUSHED AND GROUND BARITE SOLD OR USED BY PROCESSORS IN THE UNITED STATES, BY USE[1, 2]

(Thousand metric tons and thousand dollars)

Use	2009 Quantity	2009 Value	2010 Quantity	2010 Value
Barium chemicals, filler and (or) extender, glass	118	40,800	131	43,800
Well drilling	1,960	266,000	2,440	347,000
Total	2,080	307,000	2,570	391,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.
[2] Includes imports.

TABLE 4
U.S. EXPORTS OF NATURAL BARIUM SULFATE (BARITE), BY COUNTRY[1]

Country	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Brazil	4,930	$1,270	1,470	$1,020
Canada	37,700	7,020	97,200	13,600
Costa Rica	24	17	204	144
Egypt	--	--	694	134
Mexico	4,310	1,200	5,500	1,610
Oman	858	152	402	109
Trinidad and Tobago	92	38	409	174
Venezuela	202	64	2,060	583
Other[2, 3]	1,190 r	425 r	662	432
Total	49,300	10,200	109,000	17,800

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.
[2] Includes countries with full year quantities of less than 200 metric tons in 2010.
[3] Includes The Bahamas (2009), Belize (2009), Cameroon (2009), China, Ecuador, Equatorial Guinea (2010), France (2010), Germany (2010), Guatemala (2010), Israel (2010), Italy (2009), Lebanon, Malaysia, Mozambique (2009), Russia (2010), Singapore (2010), Taiwan (2009), and Thailand.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF BARITE, BY COUNTRY[1]

	2009		2010	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Crude:				
Canada	621	$17	8	$3
China	502,000	54,000	754,000	75,900
India	41,800	3,540	45,500	4,690
Japan	6	13	--	--
Malaysia	--	--	636	18
Mexico	5,590	465	18,100	1,390
Morocco	21,800	1,930	54,900	5,180
Norway	--	--	230	60
Total	572,000	60,000	873,000	87,300
Ground:				
Canada	--	--	8,060	510
China	826,000	55,400	1,170,000	87,000
Germany	569	548	1,150	582
India	23,800	1,790	38,400	3,050
Italy	--	--	27	5
Japan	88	225	1,690	365
Mexico	764	129	--	--
Netherlands	--	--	4	3
Spain	--	--	19	12
United Kingdom	--	--	86	43
Total	851,000	58,100	1,220,000	91,500
Other sulfates of barium:				
Brazil	78	39	--	--
Canada	1	2	--	--
China	3,550	2,230	4,380	2,940
Denmark	--	--	5	4
Germany	4,870	6,020	7,640	10,700
Italy	1,540	1,340	1,920	1,720
Japan	527	1,220	670	1,630
Netherlands	--	--	130	58
Spain	14	12	--	--
Switzerland	2	4	--	--
United Kingdom	(3)	3	(3)	8
Total	10,600	10,900	14,700	17,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight value.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF BARIUM CHEMICALS[1]

	2009		2010	
	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Chloride	466	$551	352	$431
Oxide, hydroxide, peroxide	2,890	5,050	4,290	4,940
Carbonate, precipitated	814	649	2,780	2,530

[1] Data are rounded to no more than three significant digits.

[2] Cost, insurance, and freight value.

Source: U.S. Census Bureau.

TABLE 7

BARITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009[e]	2010[e]
Algeria	64,787	63,098	60,088	38,000 [r, 3]	60,000
Argentina	6,276	37,979	3,170	3,416 [r, 3]	3,200
Australia[e]	21,000	16,000	21,000 [r]	20,000 [r]	21,000
Bolivia	8,943	8,245	10,900	2,069 [r, 3]	7,845 [3]
Brazil, beneficiated	19,151	13,311	23,276 [r]	38,550 [r]	40,000
Bulgaria[e, 4]	74,500	51,000	40,000	14,300	15,000
Burma	2,930	6,813	5,679	7,623 [3]	8,975 [3]
Canada	20,000	9,000	12,000	15,000	22,000 [p]
China[e]	4,400,000	4,400,000	4,600,000	3,000,000	4,000,000
France[e]	30,000	--	--	--	--
Germany	85,524	72,555 [r]	78,941	45,606 [r, 3]	50,000
India[e]	950,000	1,000,000	1,100,000	1,200,000	1,100,000
Iran[e, 5]	230,000 [r]	249,495 [3]	226,590 [r, 3]	240,000 [r]	200,000
Italy[e]	5,000	5,000	5,000	3,500	3,500
Kazakhstan[4]	120,000 [r]	130,000 [r]	170,000 [r]	170,000 [r]	200,000
Laos[e]	29,000	29,000	29,000	29,000	29,000
Mexico	206,106	185,921	140,066	151,791 [3]	134,493 [3]
Morocco[4]	525,000 [r]	500,000 [r]	590,000 [r]	520,000 [r]	650,000
Nigeria[e, 6]	6,300	5,000	5,000	5,000	5,000
Pakistan	45,169	48,044 [r]	48,000 [r]	49,000 [r]	49,000
Peru	23,800	27,369	42,660	27,875 [3]	81,087 [3]
Russia[e]	63,000	63,000	63,000	63,000	60,000
Slovakia, concentrate	16,000	11,000	12,950	8,000 [r]	10,000
Spain	45,000	35,000	--	--	--
Thailand[7]	4,549 [r]	8,631	9,180	51,895 [r, 3]	52,000
Turkey	161,993	184,041	482,740 [r]	213,187 [r, 3]	250,000
United Kingdom[e]	50,000	55,000	50,000	50,000	50,000
United States[8]	589,000	455,000	648,000	383,000 [3]	662,000 [3]
Vietnam[e]	100,000 [r]	120,000 [r]	90,000 [r]	75,000 [r]	85,000
Other[9]	4,708	2,118 [r]	3,434 [r]	3,117 [r, 3]	3,157 [3]
Total	7,910,000 [r]	7,790,000 [r]	8,570,000 [r]	6,430,000 [r]	7,850,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 23, 2011.

[3] Reported figure.

[4] Estimated marketable production, may differ from reported production data.

[5] Data are for fiscal year beginning March 21 of that stated.

[6] Considerably more barite is produced, but it is considered to be commercially unusable.

[7] Data for 2006–09 reported by Thailand Department of Primary Industries and Mines, data for 2010 from USGS.

[8] Crude barite sold or used by producers.

[9] Includes Afghanistan, Bosnia and Herzegovina, Chile, Colombia, Egypt, Guatemala, and Poland.

BAUXITE AND ALUMINA

By E. Lee Bray

Domestic survey data and tables were prepared by Linda M. White, statistical assistant, and the world production tables were prepared by Lisa D. Miller, international data coordinator.

In 2010, almost all of the 9.24 million metric tons (Mt) of bauxite consumed in the United States was imported. U.S. production and shipments of alumina (calcined equivalent) were 3.91 Mt and 3.93 Mt, respectively. An estimated 91% of domestic shipments was used for metal production. World production of bauxite totaled 209 Mt; the leading producing countries were, in descending order of production, Australia, China, and Brazil. World production of alumina was estimated to be 85.3 Mt; China, Australia, and Brazil were, in descending order, the leading producing countries.

Production

Bauxite.—For many years, domestic mines have supplied less than 1% of the U.S. requirement for bauxite, all of which was used in nonmetallurgical products, such as abrasives, chemicals, proppants, and refractories. Thus, the United States imported almost all the bauxite that it required.

Alumina.—U.S. production of alumina, which was derived exclusively from imported metallurgical-grade bauxite, was 65% higher in 2010 than in 2009 (table 2) owing to the restart of idled capacity in the fourth quarter of 2009 at a refinery in Gramercy, LA, and increased production at other refineries. Alumina production increased to satisfy domestic consumption, as net imports declined from those of the prior year. In October, a 5-year labor contract with Noranda Aluminum Holding Corp. was ratified by employees represented by the United Steelworkers union. The contract covered approximately 350 employees at the 1.2-million-metric-ton-per-year (Mt/yr) alumina refinery in Gramercy (Noranda Aluminum Holding Corp., 2010).

Consumption

Bauxite.—Domestic production and consumption data for bauxite and alumina were obtained by the U.S. Geological Survey from three voluntary surveys. The "Bauxite Consumption" survey was sent to 31 operations, 24 of which responded, representing approximately 89% of the bauxite consumed for uses other than cement listed in table 4.

Total domestic consumption of bauxite increased by 68% compared with that of 2009 as a result of the production restart at an alumina refinery late in 2009 and increased production at other refineries. In 2010, 99% of the bauxite consumed in the United States was refined to alumina [an estimated 2.33 metric tons (t) of dried bauxite was required to produce 1 t of alumina]; the remaining 1% was consumed in nonmetallurgical applications (table 4).

Alumina.—An estimated 92% of the net alumina imports and alumina shipped by U.S. alumina refineries went to primary aluminum smelters for metal production. In 2010, nine domestic primary aluminum smelters consumed 3.45 Mt of alumina, the same amount of alumina consumed in 2009. Consumption of various forms of alumina by the abrasives, chemicals, refractories, and other specialty industries accounted for the remainder of U.S. alumina use.

Prices

Most metallurgical-grade bauxite and alumina were purchased under long-term contracts, and contract terms normally were not made public. Spot prices for metallurgical-grade alumina and specialty forms of bauxite and alumina for nonmetallurgical applications, however, were published in trade journals.

The 2010 annual average values of U.S. imports of metallurgical-grade bauxite (table 5) were essentially unchanged compared with those of 2009. Alumina prices generally followed the trend in aluminum prices. The 2010 average value of U.S. imports of calcined alumina was $407 per metric ton including cost, insurance, and freight at U.S. ports. The monthly average prices for metallurgical-grade alumina are listed in table 6. Yearend price ranges for refractory-grade bauxite in China, a leading supplier, as quoted in Industrial Minerals (2010b), are listed in table 7.

World Industry Structure

Production.—In 2010, world production of bauxite increased by 7% compared with that of 2009 (table 11). Total mine production of 209 Mt was reported from 25 countries. The leading producers of bauxite were, in decreasing order of tonnage mined, Australia, China, Brazil, India, and Guinea. These countries accounted for 84% of total world production; Australia, China, and Brazil together accounted for two-thirds of the world's production. World output of alumina increased by 11% in 2010 compared with that of 2009 (table 12). The five leading producing countries were, in descending order of quantity of alumina produced, China, Australia, Brazil, India, and the United States. These countries accounted for more than three-quarters of world production; China and Australia together accounted for 57%.

Mergers, Acquisitions, and Restructuring.—Norsk Hydro ASA (Oslo, Norway) and Vale SA (Rio de Janeiro, Brazil) announced a deal in May in which Norsk Hydro would purchase Vale's bauxite, alumina, and aluminum assets in Brazil in exchange for $1.1 billion in cash plus $3.8 billion in Norsk Hydro stock. As a result of the transaction, Vale would own 22% of Norsk Hydro; Norsk Hydro would own 51% of the 460,000-metric-ton-per-year (t/yr) Albras smelter; and Norsk Hydro would increase its share of the 6.3-Mt/yr Alunorte refinery to 91% from 34% and of the 1.86-Mt/yr Companhia de Alumina do Para (CAP) refinery project to 81% from 20%. Norsk Hydro would also gain ownership of 60% of the Paragominas bauxite mine (9.9 Mt/yr capacity) with an option to purchase the remaining 40% of the mine by yearend 2015 (Norsk Hydro ASA, 2010a; Platts Metals Week, 2010b). The companies had planned to complete the transaction by yearend but closing was delayed until early in 2011 awaiting regulatory approval (Norsk Hydro ASA, 2010b).

Rio Tinto plc sold its 80% share in the Ghana Bauxite Co. Ltd. to Bosai Minerals Group Co. Ltd. in February. The Government maintained its ownership of 20% of the 800,000-t/yr Awaso Mine (Rio Tinto Alcan Inc., 2010b).

World Review

Australia.—The Australian Government announced that it was deferring implementation of a cap-and-trade program aimed at reducing greenhouse gas emissions. The proposal was withdrawn in April because of a lack of agreement in Parliament (Australian Department of Climate Change, 2010). The proposal would have included provisions for the aluminum industry and other emission-intensive industries to mitigate the costs during the first several years of implementation.

Work on expansion of BHP Billiton's Worsley refinery to 4.6 Mt/yr from 3.5 Mt/yr continued throughout the year. Completion was projected for early 2011 (BHP Billiton Ltd., 2010a).

Rio Tinto announced in November that expansion of the Yarwun refinery to 3.4 Mt/yr from 1.4 Mt/yr was being accelerated and was expected to be completed in August 2012. Work had been slowed during 2009 in response to the global financial downturn (Rio Tinto Alcan Inc., 2010c). Production at the Gove refinery was slightly lower than that of 2009 owing to unplanned maintenance in the first quarter. Production from the 3.85-Mt/yr Queensland refinery was 3% lower than that of 2009 owing to bad weather in the first quarter. Rio Tinto increased production of bauxite from the Weipa Mine by 15% to 18.6 Mt in 2010 from 16.2 Mt during 2009 to meet global demand for alumina production as prices increased (Rio Tinto plc, 2010a, p. 4; 2011, p. 15).

Aluminum Corp. of China Ltd. (Chinalco) decided not to proceed with construction of the Aurukun project in Queensland because of high costs and market conditions. The project would have included a 10-Mt/yr bauxite mine and a 2.1-Mt/yr alumina refinery. Chinalco was discussing future development of the project under new terms with the Queensland government (Aluminum Corp. of China Ltd., 2011, p. 98).

Brazil.—Alcoa World Alumina and Chemicals [a joint venture between Alcoa (60%) and Alumina Ltd. (40%)] continued to ramp-up production at the Juruti Mine, which opened in September 2009. At capacity, the mine was expected to produce 2.6 Mt/yr of bauxite that would be sent to the Alumar refinery in São Luís (Matthews, 2010).

Expansion of the Alumar refinery to 3.6 Mt/yr from 1.5 Mt/yr was completed in July 2009, and production ramp up continued throughout 2010. Production at full capacity was expected to be reached in mid-2011 instead of during the first quarter of 2010 because of issues with the ship-loading facilities. The refinery was a joint venture between Alcoa (38.4%), BHP Billiton (36%), Alumina (15.6%), and Rio Tinto (10%); Alcoa was the refinery's operator (BHP Billiton Ltd., 2010b, p. 2).

Vale continued work on the Paragominas III Mine, which, at capacity, would produce 5 Mt/yr of bauxite when completed in 2012 to be supplied to the CAP alumina refinery in Barcarena. Work also continued on the CAP refinery, which was expected to be completed and begin production by yearend 2012, with an initial production capacity of 1.9 Mt/yr. The refinery was a joint venture among Vale (61%), Norsk Hydro (20%), and Dubai Aluminium Co. Ltd. (Dubal) (19%) (Norsk Hydro ASA, 2011, p. 50–52; Vale SA, 2011).

Bauxite production by Minerasção Rio do Norte SA (MRN) increased to 17 Mt, 15% higher than the amount produced in 2009, as its mines at Oriximina, Papagalo, and Trombetas restarted idle capacity (Vale SA, 2011). MRN had a capacity to produce 19.8 Mt/yr of bauxite and was a joint venture among Vale (40%), BHP Billiton (14.8%), Rio Tinto (12%), Companhia Brasileira de Aluminio (10%), Alcoa (8.6%), Alcoa World Alumina (5%), Norsk Hydro (5%), and Abalco (4.6%).

Canada.—Production from the 1.5-Mt/yr Vaudreuil refinery in Jonquiere, Quebec, increased during 2010 after a restart of idled capacity in September 2009 as prices for alumina and aluminum increased. During the third quarter of 2010, the refinery was producing near its capacity (Rio Tinto plc, 2010b, p. 4, 15). An expansion project for the refinery's waste disposal facility was started in November and was expected to be completed in approximately 3 years (Rio Tinto Alcan Inc., 2010a).

Exploration Orbite V.S.P.A. Inc. continued construction of a pilot plant to test the recovery of alumina from aluminous clays near Grande-Vallee, Quebec. The pilot plant at Cap-Chat, Quebec, was to be operational early in 2011 (Exploration Orbite V.S.P.A. Inc., 2010).

China.—In June, Chinalco announced plans to permanently close 1 Mt/yr of obsolete alumina refining capacity by 2011 in order to comply with energy conservation and emission control directives (China Metal Market—Alumina & Aluminum, 2010b). In July, Chiping Xinfa Aluminum Co. Ltd. was ordered to shut down approximately 200,000 t/yr of aluminum capacity and 320,000 t/yr of alumina capacity at its smelter and refinery, respectively, in Liaochen, Shandong Province. The closures were implemented during the third quarter (China Metal Market—Alumina & Aluminum, 2010c).

In June, Chinalco completed an 800,000-t/yr refinery in Zunyi, Guizhou Province. An adjacent 1.7-Mt/yr bauxite mine was also completed (CRU Alumina Monitor, 2010b; Aluminum Corp. of China Ltd., 2011, p. 60). In September, Chinalco commissioned an 800,000-t/yr refinery in Nanchuan, Chongqing. The refinery would use bauxite from local sources, which reportedly contain 100 Mt of reserves. Further expansion to 1.6 Mt/yr was being planned, with a 400,000-t/yr smelter and fabrication facilities also proposed in Chongqing (American Metal Market, 2010b; Aluminum Corp. of China Ltd., 2011, p. 60).

Nanshan Longkou Donghai Alumina Co. Ltd. completed a 400,000-t/yr expansion in May and was continuing work on another expansion at its Shandong refinery. Alumina capacity at the refinery would increase to 1.6 Mt/yr from 1.2 Mt/yr when the expansion is completed in early 2011 (Platts Metals Week, 2010a). In September, Guangxi Huayin Aluminum Co. Ltd. started production from an expansion at its refinery in Huayin, Guangxi Province. The project increased capacity to 2 Mt/yr from 1.6 Mt/yr (CRU Alumina Monitor, 2010d).

In July, Shanxi Luneng Jinbei Aluminum Co. Ltd. completed the first phase of an expansion project at its alumina refinery. A second phase expansion was underway, which was to be completed in May 2011 and would increase capacity to 2 Mt/yr from 1 Mt/yr (China Metal Market—Alumina & Aluminum, 2010e). Also in July, Bosai Minerals completed an expansion of its alumina refinery in Nanchuan, Xianfeng Province, to 600,000 t/yr from 300,000 t/yr. An additional expansion was expected to be completed in 2011 and would increase capacity to 800,000 t/yr (CRU Alumina Monitor, 2010c). Yunnan Aluminum Co. Ltd. completed construction of a 400,000-t/yr alumina refinery in Wenshan, and production started during the fourth quarter. The capacity of the refinery was to be expanded to 800,000 t/yr by 2012. Bauxite was being supplied from a mine owned by Yunnan near the refinery (China Metal Market—Alumina & Aluminum, 2010h).

Guizhou Guanglu Aluminium Co. Ltd. continued construction of an 800,000-t/yr alumina refinery and powerplant in Qingzhen, Guizhou Province (Jiangsu New Century Jiangnan Environmental Protection Co., Ltd., 2010). The project was scheduled for completion by 2012, with production at full capacity expected by mid-2012.

Guangdong Galuminum Group Ltd. continued construction of an 800,000-t/yr alumina refinery in Qingzhen, Guizhou Province. The project was scheduled to be completed in mid-2011. The company was also developing a mine to supply to the refinery at a nearby bauxite deposit with 360 Mt of reserves. The mine would have a capacity of 1.6 Mt/yr when completed at the beginning of 2012 (China Metal Market—Alumina & Aluminum, 2010d).

Louyang Xiangjiang Wanji Aluminium Ltd. started work on an expansion of its alumina refinery in Louyang, Henan Province, during the second quarter of 2010. Capacity would increase to 1.4 Mt/yr from 800,000 t/yr when completed at yearend 2011 (CRU Alumina Monitor, 2010a). Shanxi Zhaofeng Aluminium Co. Ltd. started expansion of its alumina refinery in Shanxi Province to 1 Mt/yr from 400,000 t/yr. The project was expected to be completed in late 2012 (Platts Metals Week, 2010c). In September, Shandong Chiping Xinfa started construction of an alumina refinery in Jiaokou, Shanxi Province. The refinery would have a production capacity of 2.4 Mt/yr and was expected to be completed by yearend 2011 (China Metal Market—Alumina & Aluminum, 2010f). In November, Chinalco started construction on an expansion of the Guangxi alumina refinery in Pingguo, Guangxi Province, which would increase capacity to 2.5 Mt/yr from 2 Mt/yr. The refinery would also attempt to recover iron oxide from the red mud, with an expected 220,000 t/yr of iron oxide to be recovered. Expansion of the adjacent aluminum smelter would increase capacity to 550,000 t/yr from 150,000 t/yr (China Metal Market—Alumina & Aluminum, 2010a).

Guinea.—An appellate court ruling upheld the 2006 sale of the Friguia refinery and adjacent mine to United Company RUSAL (Rusal). The new Government had filed suit alleging that the sale of the 640,000-t/yr refinery by the prior regime was not legal. A lower court had ruled in favor of the Government in September 2009 (United Company RUSAL, 2010b).

Rusal increased alumina production from the Friguia alumina refinery by 13% compared with production in 2009 as a result of increasing demand and prices. Bauxite production from the Friguia and Kinda Mines also increased by 14% each (United Company RUSAL, 2011, p. 33–35).

The Sangaredi Mine produced 12.4 Mt of bauxite during the year, 11% more than the 11.2 Mt produced in 2009. Production at the mine increased during the fourth quarter of 2009 as prices and demand increased. The mine, with a capacity of 14 Mt/yr, was producing at a rate of 12.6 Mt/yr at yearend. The mine was a joint venture among the Government (49%), Alcoa (22.95%), Rio Tinto (22.95%), and Dadco Group (5.1%) (Rio Tinto plc, 2011, p. 15).

Global Alumina Corp. delayed construction of its planned bauxite mine and alumina refinery until further notice. Construction of the refinery, which would have a capacity of 3.3 Mt/yr and would use bauxite from deposits for which Global Alumina had mining concessions, had been delayed since 2009 because of the global financial downturn. The project was a joint venture with BHP Billiton, Dubal, and Mubadala Development Co. (Global Alumina Corp., 2010).

Hungary.—A spill of red mud occurred on October 4 at the Magyar Aluminium Ltd. alumina refinery in Ajka. The 400,000-t/yr refinery shut down when the impoundment dam failed. The flood of red mud flowing through nearby villages killed 10 people and injured more than 100 others. Production was restarted on October 17 (Earth Times News, 2010; Gulyas, 2010; Magyar Aluminium Ltd., 2010).

India.—National Aluminium Co. Ltd. was working to complete expansion of its refinery in Damanjodi by early 2011. The project would increase production capacity to 2.1 Mt/yr from 1.6 Mt/yr (National Aluminium Co. Ltd., 2010, p. 8).

Hindalco Industries Ltd. continued progress on several major expansion projects. The Belgam refinery was ramping up production to 316,000 t/yr from 138,000 t/yr. Construction of the 1.5-Mt/yr Utkal alumina refinery was continuing, with production scheduled to start in July 2011. Planning continued for the Aditya aluminum complex in Orissa, which would have a 359,000-t/yr smelter, a 1.5-Mt/yr alumina refinery, and a 900-megawatt (MW) captive powerplant. Completion of the smelter was planned for October 2011, and completion of the refinery was expected in 2013 (Hindalco Industries Ltd., 2010).

Vedanta Resources plc was awaiting mining permits for the Niyamgiri Mine, expected to be the main source of bauxite for the Lanjigarh refinery. As a result, expansion of the Lanjigarh refinery to 2 Mt/yr from 1.4 Mt/yr was put on hold, and work on the 325,000-t/yr Korba III smelter and the 125,000-t/yr Jharsuguda II smelter was also suspended temporarily (Vedanta Resources plc, 2010).

Indonesia.—PT Aneka Tambang (Antam) ended production from the Kijang Mine in late 2009 and began reclamation work on the site, although sales of stockpiled bauxite continued throughout 2010. Construction of a 300,000-t/yr chemical-grade alumina refinery at Tayan was expected to begin in April 2011, and the refinery was expected to begin production in early 2014. Bauxite for the refinery would come from a nearby deposit that was being developed. In addition to the Tayan prospect, Antam continued exploration for bauxite in several other prospects in West Kalimantan (PT Aneka Tambang, 2011, p. 6, 14).

Ireland.—Rusal increased the production rate at the Aughinish alumina refinery to its full capacity of 1.5 Mt/yr as prices rose during the year. Production in 2010 was 1.85 Mt, 49% higher than the 1.25 Mt produced during 2009 (United Company RUSAL, 2011, p. 33–34).

Jamaica.—Rusal restarted production at the Ewarton alumina refinery in June, as prices rose during the year. Alumina production for the year was 238,000 t, 56% higher than the 153,000 t produced during 2009. Bauxite production was 900,000 t in 2010, compared with the 100,000 t produced in 2009. Production at the refinery and nearby mine had been shut down in the first quarter of 2009 in response to falling prices and demand (United Company RUSAL, 2010a; 2011, p. 33–35).

Kazakhstan.—Eurasian Natural Resources Corp. (ERNC) was expanding the capacity of its alumina refinery to 1.7 Mt/yr from 1.25 Mt/yr. Completion of the project was scheduled for mid-2011 and would supply ENRC's nearby smelter, where an expansion project was completed in May 2010, in addition to supplying other customers (Eurasian Natural Resources Corp., 2010, p. 17).

Montenegro.—Central European Aluminum Co. continued to modernize its Podgorica smelter and alumina refinery. Although originally planned for completion by yearend, some work was delayed until early 2011. Capacity of the smelter would increase to 156,000 t/yr from 120,000 t/yr, and capacity of the alumina refinery would increase to 400,000 t/yr from 280,000 t/yr (Central European Aluminum Co., 2010).

Russia.—Production of alumina in Russia was slightly higher in 2010 than that in 2009. Bauxite production was 5% less than that in 2009 owing to lower output at the North Urals Mine. Reserves near the surface were nearing depletion in two areas of the deposit. Rusal was developing an underground expansion of the mine that would extend the life of the mine, although a completion date was not announced (United Company RUSAL, 2011, p. 33–35).

Saudi Arabia.—In October, Saudi Arabian Mining Co. (Ma'aden) and Alcoa began construction of the 740,000-t/yr Raz as Zawr smelter and 380,000-t/yr rolling mill. The project, expected to be completed in 2013, also included a 4-Mt/yr bauxite mine at Al Ba'itha and a 1.8-Mt/yr alumina refinery in Raz as Zawr that were expected to be completed in 2014. The smelter would use imported alumina until the mine and refinery are completed. Ma'aden owned 74.9% of the joint venture, and Alcoa owned 25.1% (Alcoa Inc., 2010).

Turkey.—Demireller Mining Co. was working to expand bauxite production to 750,000 t/yr from 400,000 t/yr by yearend 2011. Demireller mined bauxite from two sites in the Taurus Mountains near Mersin and planned to produce bauxite at other sites. The company has 10 Mt of bauxite reserves in the region (Industrial Minerals, 2010a).

Venezuela.—Production from Corporacion Venezolana de Guayana Bauxilum C.A.'s (Bauxilum) 6-Mt/yr Los Pijiguaos Mine was shut down from May through July as a result of low water levels in the Orinoco River. Mining and shipments resumed in July as river levels rose. The river was used to ship bauxite to Bauxilum's 1.8-Mt/yr Ciudad Guayana alumina refinery. Alumina production at Ciudad Guayana continued at a lower rate using bauxite imported from Brazil while shipments from Los Pijiguaos were suspended (American Metal Market, 2010a).

Vietnam.—In February, Vietnam National Coal and Mineral Industries Group (Vinacomin) and Chinalco started construction of a 600,000-t/yr alumina refinery and an adjacent bauxite mine in Lam Dong. The refinery and mine were expected to be completed in 2012 (China Metal Market—Alumina & Aluminum, 2010g). Vinacomin and Chinalco were also constructing a 650,000-t/yr alumina refinery in Nhan Co, Dak Nong Province. The refinery and mine were expected to be completed in mid-2013 (ABN Business News, 2010).

Atlantic Ltd. continued studies on developing the Bao Loc bauxite deposit. Studies for a refinery and smelter would also be conducted if a bauxite mine proved feasible (Atlantic Ltd., 2010).

Outlook

Consumption of bauxite and consumption of alumina were expected to closely follow the trend of aluminum consumption. Alumina prices generally continued their upward trend in the first quarter of 2011, exceeding the high price range of early 2008, but remained volatile. At yearend, one domestic alumina refinery that had been closed since 2006 was considering reopening to meet increasing demand, and in early 2011, the company announced that the refinery would reopen later in the year. Consumption of bauxite and consumption of alumina in emerging economies were expected to increase as these economies continue to recover from the effects of the global recession. However, policies aimed at slowing growth in China may slow the rate of growth of consumption of aluminum in that nation, affecting bauxite and alumina demand.

Consumer credit issues in the United States and Western Europe were expected to continue through 2011. The continuing uncertainty of the impact of sovereign debt issues in Europe also raised concerns about consumer demand. Although consumption was recovering, decreased demand for aluminum in developed economies still recovering from the economic events of 2008 could keep global bauxite and alumina production for 2011 through 2012 only slightly higher than 2008 production. Easing of credit to bauxite and alumina companies was expected to enable more expansion projects to resume progress in many parts of the world, especially in locations with substantial deposits of high-quality bauxite.

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TABLE 1
SALIENT BAUXITE STATISTICS[1]

(Thousand metric tons)

	2006	2007	2008	2009	2010
United States:					
Exports, as shipped:					
Crude and dried	20	15	14	9	21
Calcined	14	8	10	21 [r]	19
Imports for consumption, as shipped:					
Crude and dried	11,600	9,840	10,500	6,970	8,120
Calcined	752	808	1,110	461	690
Consumption, dry equivalent	12,300	10,200	9,550	5,490 [r]	9,240
World, production	193,000	204,000	211,000	196,000 [r]	209,000 [e]

[e]Estimated. [r]Revised.

[1]Data are rounded to no more than three significant digits.

TABLE 2
SALIENT ALUMINA STATISTICS[1]

(Thousand metric tons)

	2006	2007	2008	2009	2010
United States:					
Production:					
Calcined alumina	4,630 [r]	3,770	3,900	2,130 [r]	3,570
Other alumina[2]	619 [r]	717	610	370 [r]	522
Total:					
As produced or shipped[3]	5,250 [r]	4,490	4,510	2,500 [r]	4,100
Calcined equivalent	5,030 [r]	4,240	4,300	2,370 [r]	3,910
Shipments:					
Calcined alumina	4,580	3,770	3,910	2,130 [r]	3,580
Other alumina [2]	564	667	582	365 [r]	526
Total:					
As produced or shipped[3]	5,150	4,440	4,490	2,500 [r]	4,110
Calcined equivalent	4,950	4,200	4,290	2,370 [r]	3,930
Stocks, yearend[4, 5]	948 [r]	446 [r]	642 [r]	257 [r]	250
Imports for consumption[5]	1,860	2,440	2,530	1,860	1,720
Exports [5]	1,540	1,160	1,150	946	1,520
Consumption, apparent[5, 6]	5,240 [r]	6,010 [r]	5,490 [r]	3,660 [r]	4,120
World, production [5]	72,400 [r]	77,900 [r]	82,500 [r]	76,700 [r]	85,300 [e]

[e]Estimated. [r]Revised.

[1]Data are rounded to no more than three significant digits.

[2]Trihydrate, activated, tabular, and other aluminas. Excludes calcium and sodium aluminates.

[3]Includes only the end product if one type of alumina was produced and used to make another type of alumina.

[4]Excludes consumers stocks other than those at primary aluminum plants.

[5]Calcined equivalent.

[6]Defined as domestic production plus imports minus exports plus adjustments for industry stock changes.

TABLE 3

CAPACITIES OF DOMESTIC ALUMINA PLANTS, DECEMBER 31[1,2]

(Thousand metric tons per year)

Company and plant	2009	2010
Alcoa Inc., Point Comfort, TX	2,300	2,300
Noranda Alumina LLC, Gramercy, LA	1,200 r	1,200
Ormet Corp., Burnside, LA	540 r	540
Sherwin Alumina Co., Corpus Christi, TX[3]	1,600	1,600
Total	5,640 r	5,640

[r] Revised.

[1] Capacity may vary depending on the bauxite used.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Owned by Glencore International AG.

TABLE 4

U.S. CONSUMPTION OF BAUXITE, BY INDUSTRY[1]

(Thousand metric tons, dry equivalent)

Industry	2009[r]	2010
Alumina	5,330	9,110
Other[2]	153	137
Total	5,490	9,240

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes abrasive, chemical, and refractory uses.

TABLE 5

AVERAGE VALUE OF U.S. IMPORTS OF CRUDE AND DRIED BAUXITE[1]

(Dollars per metric ton)

Country	2009 Port of shipment f.a.s.[2]	2009 Delivered to U.S. ports c.i.f.[3]	2010 Port of shipment f.a.s.[2]	2010 Delivered to U.S. ports c.i.f.[3]
Brazil	35.53	48.84	28.47	48.32
Guinea	32.69	46.86	27.78	47.92
Jamaica	20.78	24.24	25.88	34.03
Sierra Leone	29.50 r	42.00 r	--	--
Weighted average	29.80	50.97 r	29.41	50.60

[r] Revised. -- Zero.

[1] Computed from quantity and value data reported to U.S. Customs Service and compiled by the U.S. Census Bureau. Not adjusted for moisture content of bauxite or differences in methods used by importers to determine value of individual shipments.

[2] Free alongside ship valuation.

[3] Cost, insurance, and freight valuation.

TABLE 6
AVERAGE VALUE OF U.S. IMPORTS OF ALUMINA[1]

(Dollars per metric ton)

	2009	2010
January	322	384
February	277	400
March	248	418
April	270	500
May	295	419
June	292	425
July	324	398
August	399	352
September	314	402
October	400	393
November	360	400
December	420	394
Average	327	407

[1] Metallurgical grade, cost, insurance, and freight valuation. Computed from quantity and value data reported to U.S. Customs Service and compiled by the U.S. Census Bureau.

TABLE 7
REFRACTORY GRADE BAUXITE PRICES

(Dollars per metric ton)

Material	2009[1]	2010[2]
China:		
Guizhou Province, rotary kiln, lump	390–410	470–525
Shanxi Province, rotary kiln, lump	470–500	495–535
Shanxi Province, round kiln, lump	480–500	500–535
Guyana, rotary kiln, lump	450–510	460–510

[1] Port of shipment, 88% Al_2O_3, free-on-board ship valuation, yearend.

[2] Port of shipment, 87% Al_2O_3, free-on-board ship valuation, yearend.

Source: Industrial Minerals.

TABLE 8

U.S. EXPORTS AND IMPORTS FOR CONSUMPTION OF BAUXITE, CRUDE AND DRIED, BY COUNTRY[1]

(Thousand metric tons)

Country	2009	2010
Exports:		
Canada	6 [r]	15
Germany	(2)	(2)
Venezuela	(2)	1
Other	2 [r]	6
Total	9 [r]	21
Imports:		
Brazil	1,410	1,640
Guinea	1,910	2,130
Jamaica[3]	3,200	4,300
Sierra Leone	308	--
Other	152 [r]	45
Total	6,970	8,120

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

[3] Data from the Jamaica Bauxite Institute.

Note: Total U.S. imports of crude and dried bauxite as reported by the U.S. Census Bureau were as follows: 2009—6.77 million metric tons (Mt) and 2010—5.19 Mt.

TABLE 9

U.S. EXPORTS AND IMPORTS FOR CONSUMPTION OF CALCINED BAUXITE, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2009				2010			
	Refractory grade		Other grade		Refractory grade		Other grade	
Country	Quantity	Value[2]	Quantity	Value[2]	Quantity	Value[2]	Quantity	Value[2]
Exports:								
Canada	7	748	(3)	30	8	891	1	35
Korea, Republic of	11	8,800	--	--	--	--	--	--
Mexico	1 [r]	563	(3)	602	1	265	8	5,740
Other	1	125 [r]	(3)	17	(3)	228	1	242
Total	20	10,200	1	649	9	1,380	10	6,020
Imports:								
Australia	--	--	17	1,040	--	--	85	1,910
Brazil	114	54,300	46	1,680 [r]	167	76,000	70	3,270
China	12	6,190 [r]	11	6,240 [r]	74	34,000	3	677
Greece	74	3,880 [r]	--	--	104	5,650	--	--
Guyana	21	8,640	164	9,560 [r]	37	14,200	148	9,980
Other	(3)	29 [r]	1	50 [r]	1	45	2	126
Total	222	73,000 [r]	239	18,600	384	130,000	307	16,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Value at foreign port of shipment as reported to U.S. Customs Service.

[3] Less than ½ unit.

TABLE 10
U.S. EXPORTS AND IMPORTS FOR CONSUMPTION OF ALUMINA, BY COUNTRY[1]

(Thousand metric tons, calcined equivalent, and thousand dollars)

	2009		2010	
Country	Quantity	Value[2]	Quantity	Value[2]
Exports:				
Canada	332	109,000	719	238,000
France	125	37,800	58	25,500
Iceland	277	63,200	217	63,300
Mexico	57	38,000	83	50,000
Netherlands	2	7,750	182	60,000
Norway	79	17,100	(3)	233
Other	74 [r]	215,000	265	287,000
Total	946	488,000	1,520	724,000
Imports:				
Australia	700 [r]	159,000	572	163,000
Brazil	367	87,300	233	72,400
Canada	48	51,200	62	41,600
France	12	20,900	23	30,600
Germany	71	84,100	81	109,000
Jamaica	248	62,300	84	30,000
Suriname	381	90,300	488	143,000
Venezuela	--	--	56	18,200
Other	28 [r]	58,200	120	103,000
Total	1,860	613,000	1,720	711,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Value at foreign port of shipment as reported to U.S. Customs Service.

[3] Less than ½ unit.

TABLE 11
BAUXITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2006	2007	2008	2009	2010[e]
Australia	61,780	62,398	61,389	65,231	68,414 [3]
Bosnia and Herzegovina	854	867	1,018	556 [r]	650
Brazil	23,236	25,461	28,098	25,628 [r]	28,100 [p]
China[e]	27,000	30,000	35,000	40,000	44,000
Dominican Republic	500	500	400	--	--
Ghana	842	748	802 [r]	440	170
Greece	2,163	2,126	2,176	2,100	2,100
Guinea[4]	18,784	18,519	18,400	15,600	17,400
Guyana[4]	1,479	2,243	2,092	1,760	1,760
Hungary	538	546	511	317	350
India	13,940	20,343	21,210	16,000	18,000
Indonesia	1,502	1,251	1,152	811 [r]	105 [3]
Iran	500	500	500	500	500
Jamaica[4, 5]	14,865	14,568	14,363	7,817	8,540 [3]
Kazakhstan	4,884	4,963 [r]	5,160	5,130	5,310 [3]
Malaysia	92	157	295	263 [r]	270
Montenegro	659	667	672	46	61 [3]
Mozambique	11	9	5	4	5
Pakistan	13 [r]	27 [r]	32 [r]	37 [r]	39
Russia	6,300	5,775	5,675	5,775	5,475 [3]
Sierra Leone	1,071	1,169	954	757	1,089 [3]
Suriname	4,924	5,054	5,200	4,000	4,000 [p]
Tanzania	5	5	21 [r]	123 [r]	130
Turkey[7]	771	344	350 [e]	200 [r]	350
United States	NA	NA	NA	NA	NA
Venezuela	5,928	5,500	5,500 [e]	2,500 [e]	2,500 [p]
Vietnam[e]	60 [r]	80 [r]	80 [r]	80 [r]	80
Total	193,000	204,000	211,000	196,000 [r]	209,000

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 28, 2011.

[3] Reported figure.

[4] Dry bauxite equivalent of crude ore.

[5] Bauxite processed for conversion to alumina in Jamaica plus kiln-dried ore prepared for export.

[6] Montenegro and Serbia formally declared independence in June 2006 from each other and dissolved their union.

[7] Public-sector production only.

TABLE 12
ALUMINA: WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Thousand metric tons)

Country	2006	2007	2008	2009	2010[e]
Australia	18,312	18,844	19,321	19,948	19,956 [4]
Azerbaijan	363	185	165	80 [r, e]	--
Bosnia and Herzegovina	394 [r]	304	294	192 [r]	230
Brazil	6,793	7,078 [r]	7,822 [r]	8,625 [r, 4]	9,000
Canada	1,281	1,300 [e]	1,370	1,125	1,301 [4]
China[e]	13,700	19,500	22,800	23,800	29,000
France[e]	600	600	630 [4]	348 [4]	481 [4]
Germany	1,393	1,388	1,395	1,154	1,485 [4]
Greece	750	750	750	780	760
Guinea	530	527	593	530	597
Hungary[e]	301	301	299	185	200
India[e]	2,800	2,900	3,000	3,700	4,000
Iran[e]	250	250	200	250	270
Ireland	1,816	1,803	1,890	1,245	1,850 [4]
Italy	1,103	1,069	1,045	92	-- [4]
Jamaica	4,099	3,941	3,996	1,774	1,591 [4]
Japan[e, 5]	330	300	320	310	300
Kazakhstan	1,515	1,556	1,600	1,608	1,640 [4]
Montenegro	237	240	220	59	-- [4]
Romania	622	23	--	44	414
Russia	3,265	3,333	3,112	2,794	2,857 [4]
Spain[e, 6]	1,000	1,500	1,500	1,500	1,500
Suriname	2,153	2,270	2,156	1,178	1,200
Turkey[e]	150 [4]	160	160	100 [r]	160
Ukraine	1,672	1,656	1,673	1,524	1,534 [4]
United States	5,030 [r]	4,240	4,300	2,370 [r]	3,910 [4]
Venezuela[e]	1,892 [4]	1,900	1,900	1,370 [r]	1,100
Total	72,400 [r]	77,900 [r]	82,500 [r]	76,700 [r]	85,300

[e] Estimated. [r] Revised. -- Zero.

[1] Figures represent calcined alumina or the total of calcined alumina plus the calcined equivalent of hydrate when available; exceptions, if known, are noted.

[2] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[3] Table includes data available through July 28, 2011.

[4] Reported figure.

[5] Data presented are for alumina used principally for specialty applications. Information on aluminum hydrate for all uses is not adequate to formulate estimates of production levels. Production of aluminum hydroxide, in metric tons: 2006—720,000; 2007—700,000; 2008—700,000; 2009—710,000; and 2010—700,000.

[6] Hydrate.

BERYLLIUM

By Brian W. Jaskula

Domestic survey data and tables were prepared by Eraina C. Dixon, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

U.S. mine shipments of beryllium ore in 2010 increased by 50% from those of 2009, and ore consumption for the production of beryllium hydroxide increased by 33% (table 1). Defense Logistics Agency, DLA Strategic Materials of the U.S. Department of Defense (DOD) offered and sold selected beryllium materials from the National Defense Stockpile (NDS). On the basis of estimated contained beryllium, total U.S. imports and exports of beryllium materials were higher than those of 2009.

Beryl is frequently stockpiled for later processing. China is thought to be a significant producer, but does not report its beryl production. As a result, world production and the U.S. share of world production have a high degree of uncertainty. In 2010, estimated world beryllium mine production increased by 41% compared with that of 2009 (table 4). The United States accounted for about 88% of estimated world production.

Beryllium is gray in color and one of the lightest metals. Its other physical and mechanical properties—outstanding stiffness-to-weight and strength-to-weight ratios, one of the highest melting points of all light metals, high specific heat, excellent thermal conductivity, outstanding dimensional stability over a wide range of temperatures, reflectivity, the lowest neutron absorption cross section of any metal and a high neutron-scattering cross section, and transparency to x rays—make it useful for many applications. Beryllium is used primarily as beryllium-copper alloys, beryllium oxide ceramics, and beryllium metal in a wide variety of products in aerospace, automotive (ignition components), computer (computer chip heat sinks), defense, electronics (highly conductive and strong wire), heavy machinery, home appliance (microwave guides), industrial component (bearings and bushings), instrumentation and control system, medical, nuclear, oil and gas drilling, plastic molding, telecommunications, undersea and marine, and other applications.

High-purity beryllium was ruled both a strategic and a critical material by the U.S. Department of Defense Strategic Materials Protection Board. The Board found that domestic beryllium production capabilities had abated and required the DOD to continue to take special actions to maintain a long-term domestic supply (U.S. Department of Defense, Office of the Secretary, 2009).

Only two beryllium minerals are of commercial importance for the production of beryllium. Bertrandite, which contains less than 1% beryllium, is the principal beryllium mineral mined in the United States. Beryl, which contains about 4% beryllium, is the principal mineral mined in the rest of the world. Aquamarine, bixbite, emerald, goshenite, heliodor, and morganite are gem forms of the mineral beryl. More information on gem-quality beryl and chrysoberyl can be found in the Gemstones chapter of the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals.

Legislation and Government Programs

Defense Production Act.—DOD, under its Defense Production Act Title III Program with Materion Corp. (formerly known as Brush Engineered Materials Inc.), continued with phase 2 of its Technology Investment Agreement for the construction and startup of a $90.3 million primary beryllium facility in Elmore, OH. The objective of the partnership between DOD and Materion was to ensure a long-term domestic supply of primary beryllium, the feed material used to make beryllium metal products. Materion was to provide assets, research and development, and technology valued at approximately $23.2 million to the project, with the remaining balance to be funded by DOD. Construction was expected to be completed by early 2011. Plant capacity was reported to be 73 metric tons per year (t/yr) of high-purity beryllium metal, and approximately two-thirds of the facility's output was to be allocated for defense and Government-related end uses, with the remaining output going to the private sector (Smith Horn, 2008; Metal Bulletin, 2010; Materion Corp., 2011a, p. 9).

National Defense Stockpile.—The United States maintained a stockpile of strategic materials for use during a national emergency. As of December 31, 2010, the NDS goal for hot-pressed beryllium metal powder was 45 metric tons (t) (table 2). The Annual Materials Plan for fiscal year 2010, which represented the maximum quantities of beryllium materials that could be sold from October 1, 2009, through September 30, 2010, was as follows: 1 t of beryl ore (approximately 36 kilograms of beryllium content), actual quantity limited to remaining sales authority or inventory; and 54 t of beryllium metal (table 2). The DNSC shipped 29 t of beryllium metal in 2010. NDS calendar yearend inventories of beryllium materials are listed in table 2 (U.S. Department of Defense, 2011, p. 6).

Production

Domestic production and consumption statistics for beryllium-containing ores, as listed in tables 1 and 4, were based on data collected by the USGS by means of two voluntary surveys of U.S. operations. A small number of unidentified producers may have shipped negligible quantities of byproduct beryl, but these have not been included. In 2010, domestic mine shipments were greater than those of 2009.

The United States is one of only three countries known to process beryllium ores and concentrates into beryllium products. Materion converted bertrandite from open pit mines in the

Topaz-Spor Mountain region of Juab County, UT, along with imported beryl, into beryllium hydroxide at its operations near Delta, UT. Some of the beryllium hydroxide was shipped to Elmore, where Materion converted it into beryllium-copper master alloy (BCMA), metal, or oxide, and some was sold to NGK Insulators, Ltd. of Japan.

As part of its effort to become a vertically integrated supplier of beryllium products, IBC Advanced Alloys Corp. (Vancouver, British Columbia, Canada) continued to focus on three distinct business areas in 2010—beryllium exploration, downstream manufacturing of beryllium products, and beryllium research. In September, Fugro Airborne Surveys Corp. (Leidschendam, Netherlands) completed an airborne geophysical survey of IBC's prospective beryllium properties in Juab County, UT, which are adjacent to Materion's beryllium mine at Spor Mountain. The results were expected to delineate the most likely areas of beryllium mineralization that, with subsequent ground investigation, would provide exploratory drill hole targets to begin quantifying IBC's beryllium resources (Metal-Pages, 2010; IBC Advanced Alloys Corp., 2011, p. 9).

In June, IBC entered into a 6-month arrangement with Hydrogen Link, a materials research company focused on hydrogen storage and fuel cell technologies, in a combined effort to research and implement the use of lithium beryllium hydrides and other metal hydrides for the storage of hydrogen. By yearend, IBC was reviewing the possibility of commercializing beryllium-based hydrogen storage technology with potential industry partners (IBC Advanced Alloys Corp., 2011, p. 7).

IBC, in partnership with Purdue University and Texas A&M University, continued research into a new type of beryllium-oxide-(BeO-) enhanced nuclear fuel. IBC funded a 2-year, $500,000 research project by Purdue University's Department of Nuclear Engineering to investigate the possibility of producing a longer lasting, more efficient, and safer nuclear fuel by the addition of BeO to the uranium oxide pellet. Currently produced uranium oxide fuels, while stable and safe, are not efficient at conducting heat, which limits the power generated and causes fuel pellets to crack and degrade prematurely, necessitating replacement before the fuel has been entirely used. The addition of BeO may help cool the fuel pellet, allowing it to operate at a lower temperature and be used for a longer time, resulting in a more efficient burning of the fuel. A lower temperature would also allow for safer, more flexible reactor operation. If successful, the BeO-enhanced nuclear fuel pellet could increase demand for beryllium substantially (Mandel, 2008; Venere and Sequin, 2008; IBC Advanced Alloys Corp., 2011, p. 6).

In September, junior mineral exploration company BE Resources Inc. (Toronto, Ontario, Canada) commenced drilling at its Warm Springs Beryllium Project in New Mexico. Five exploration boreholes were to be drilled in an effort to define the beryllium resource of the company's mining claims within New Mexico's Sierra and Socorro Counties. By yearend, assay results were reported for two of the five boreholes, with the remaining assays to be reported in 2011 (BE Resources Inc., 2010a, b).

Environment

Because of the toxic nature of beryllium, various international, national, and State guidelines and regulations have been established regarding beryllium content in air, water, and other media. Industry must maintain careful control of the quantity of beryllium dust, fumes, and mists in the workplace. Control of potential health hazards adds to the final cost of beryllium products (Rossman, Preuss, and Powers, 1991, p. 277–281; Smith, Ingerman, and Amata, 2002, p. 11–15, 193–200).

Consumption

U.S. apparent consumption of all beryllium materials, as calculated from mine shipments, net trade, and changes in Government and industry stocks, was estimated to be about 456 t of contained beryllium in 2010, which was an increase of 164% from the 173 t calculated for 2009. The increase in apparent consumption was the result of increased shipments of beryllium metal from the NDS, increased imports of all beryllium materials and products, and increased shipments of bertrandite by Materion.

Since the closure of Materion's primary beryllium production facility in Elmore in 2000, the company has met its beryllium metal requirements by purchasing materials from the NDS and foreign producers. Materion's Beryllium and Beryllium Composites unit manufactured products of beryllium metal and two families of metal-matrix composites—one made from aluminum and beryllium and the other made from beryllium and BeO. The products, in the form of foil, rods, sheets, tubes, and a variety of customized shapes, were produced at plants in Elmore and in Fremont, CA. Beryllium product sales increased by 32% compared with those of 2009. Key growth sectors were defense and science applications, primarily aerospace and missile systems; industrial component and commercial aerospace applications; and medical and industrial x-ray applications. Sales of high-end beryllium speaker domes increased modestly in 2010 compared with those of 2009 (Materion Corp., 2011a, p. 32–33).

Materion's Beryllium and Beryllium Composites unit produced BeO ceramic products for aerospace, defense, electronics, medical, semiconductor, telecommunications, and wireless applications at its plant in Tucson, AZ. Sales of ceramic products increased by more than 50% in 2010 compared with those of 2009 owing largely to increased shipments for applications within the telecommunications infrastructure market (Materion Corp., 2011a, p. 33).

Materion's Performance Alloys unit produced copper- and nickel-based alloy products, the majority of which contained beryllium. Alloy strip products (which were used as connectors, contacts, relays, shielding, and switches) and alloy bulk products (including bar, plate, rod, tube, and customized forms) were produced at plants in Elmore and in Shoemakersville, PA. In 2010, the total shipment volume of alloy strip products was 56% greater than that of 2009, owing to increased consumption from the appliance, automotive electronics, and consumer electronics markets. The total shipment volume of bulk alloy products increased by 70% compared with that of 2009—largely owing to increased consumption from the commercial aerospace and industrial components markets, and the oil and gas sector of the energy market (Materion Corp., 2011a, p. 30–31).

Materion had a long-term supply arrangement with JSC Ulba Metallurgical Plant (UMP), which was part of Kazakhstan's National Atomic Company Kazatomprom JSC, and its marketing representative RWE NUKEM, Inc. (Danbury, CT) to purchase BCMA through 2011. In 2010, Materion purchased beryllium-containing materials valued at $2.7 million (Materion Corp., 2011a, p. 77).

In 2010, as part of IBC's effort to develop downstream beryllium manufacturing capabilities, the company acquired Beralcast Corp., a privately held specialty alloy manufacturing business based in Nashua, NH, which owned proprietary and patented technology for a castable beryllium aluminum alloy currently used in a variety of aerospace and advanced technology applications. IBC previously acquired Specialloy Copper Alloys, LLC (New Madrid, MO), an established specialty alloy manufacturer. Specialloy had significant unused manufacturing capacity, which was expected to be upgraded by IBC for beryllium-copper casting products. IBC also owned Freedom Alloys Inc. (Royersford, PA), a primary producer-supplier of beryllium-copper casting and master alloy ingot products, and Nonferrous Products Inc. (Franklin, IN), a specialty alloy processing company and manufacturer of forged copper, beryllium-copper, and bronze alloys (IBC Advanced Alloys Corp., 2010, p. 2–7).

In March, IBC signed long-term beryllium supply agreements with Kazatomprom's UMP agreeing to three specific initiatives. UMP and IBC committed to multiple-year supply commitments for beryllium metal and BCMA, to explore mutually beneficial strategic partnerships, and to assess the feasibility of a Kazakhstan-based high-volume BeO production facility to support IBC's beryllium-enhanced nuclear fuel initiative (IBC Advanced Alloys Corp., 2010, p. 2).

IBC teamed with Sentech, Inc., a Washington, DC-based clean-energy consulting company, to commercialize applications of beryllium and BeO in the wind energy and turbine market. IBC and Sentech were to assess the feasibility of an advanced plasma-based method of applying a BeO coating to beryllium, beryllium copper, and aluminum bronze. A BeO coating on bearings would increase the wear resistance in wind turbines and therefore increase reliability and reduce the costs of operation (IBC Advanced Alloys Corp., 2011, p. 7).

Other domestic producers of beryllium alloy products included Applied Materials Science, Inc., Concord, MA; NGK Metals Corp. (a subsidiary of NGK Insulators, Ltd.), Sweetwater, TN; and Olin Corp.'s Brass Division, East Alton, IL. American Beryllia Inc. produced beryllium oxide ceramic products at its plant in Haskell, NJ.

Recycling

Beryllium was recycled primarily from new scrap generated during the manufacture of beryllium-containing components. Detailed data on the quantities of recycled beryllium are not available but may represent as much as 10% of U.S. apparent consumption (Cunningham, 2004).

Foreign Trade

U.S. foreign trade in beryllium materials, as reported by the U.S. Census Bureau, is summarized in table 3. On the basis of estimated contained beryllium, beryllium exports increased by 69% compared with those of 2009. Canada and the United Kingdom were the major recipients of these materials. On the basis of estimated contained beryllium, total beryllium imports were more than 10 times higher than those of 2009. Russia was, by far, the leading supplier of beryllium metal to the United States, while China, Japan, and Kazakhstan were significant suppliers of other beryllium materials.

Net import reliance as a percentage of apparent consumption is used to measure the adequacy of current domestic beryllium production to meet U.S. demand. Net import reliance was defined as imports minus exports plus adjustments for Government and industry stock changes. Releases from stocks, including shipments from the NDS, were counted as part of import reliance, regardless of whether the materials were imported or produced in the United States. For 2010, net import reliance as a percentage of apparent consumption was estimated to be about 61% compared with about 31% in 2009. The increase was primarily the result of the large increase in beryllium metal imports from Russia.

World Review

China.—Yingtan Ulba Shine Metal Materials Co. Ltd. (a joint venture between UMP and Ningbo Shengtai Electronic Metal Materials Co. Ltd.) operated a plant that produced flat-rolled products from high-strength, conductive beryllium-copper alloys. Plant capacity was reported to be about 2,000 t/yr (gross weight) for all products (Interfax Russia & CIS Metals and Mining Weekly, 2009; Kazakhstan International Business Magazine, 2009).

Kazakhstan.—Kazatomprom reported production of 1,817 t of beryllium materials (including alloys and ceramics), an increase of 155% from the 712 t produced in 2009. The company's beryllium sales revenues were 80% greater than those of 2009. UMP supplied about 24% of beryllium products to the world market in 2010, compared with 3% in 1999. UMP reportedly produced from stockpiled beryllium concentrate imported mainly from Russia. The concentrate stockpile, which was built up before the breakup of the Soviet Union, was forecast in 2003 to be sufficient to support production for about 30 years (Metal Bulletin, 2003; McNeil, 2006; Kazatomprom JSC, 2011, p. 37, 107).

Kazatomprom signed an agreement with Toshiba Corp. (Tokyo, Japan) in 2010 to establish a joint venture for the research, exploration, production, and sales of rare metals, including beryllium. Previously, as part of Japan's efforts to reduce its dependence on crude oil from the Middle East, Toshiba made an agreement with Kazatomprom in 2008 to secure supplies of rare metals and reactor components for Toshiba's nuclear power business. The agreement expanded on an existing deal under which Kazatomprom supplied uranium for Toshiba-built nuclear plants (Soble and Gorst, 2008; Kazatomprom JSC, 2011, p. 32).

Russia.—East Siberian Metals Corp. (a subsidiary of Metropol Group) and UMP completed the predesign phase for resuming ore mining at the Yermakovskoye beryllium deposit in the Siberian Republic of Buryatiya and the technical design of the processing plant. The new plant would produce beryllium hydroxide, which was expected to be delivered to China, Japan, and Kazakhstan for processing into beryllium metal and beryllium alloys. Yermakovskoye was considered to be the largest beryllium deposit in Russia. Construction of the processing plant was expected to begin in 2013 (Metropol Investment Financial Co. Ltd., 2009; MBC Corp., 2010).

Outlook

The United States is expected to remain self-sufficient with respect to most of its beryllium requirements. At yearend 2010, Materion reported proven bertrandite reserves in Juab County, UT, of 5.81 million dry metric tons with an average grade of 0.266% beryllium. This represented about 15,500 t of contained beryllium. Materion owned approximately 95% of its proven mineral reserves and leased the remainder (Materion Corp., 2011a, p. 42–43).

It was expected that the 2011 U.S. shipments of beryllium-copper strip products and beryllium bulk products would increase from those of 2010 owing to increased demand from the aerospace, automotive electronics, industrial components, oil and gas, and telecommunications infrastructure markets. Increased demand for beryllium-based metals and metal matrix composites was anticipated from commercial applications, including nonmedical and industrial x-ray products, and semiconductor processing equipment (Materion Corp., 2011b).

Research and consulting firm Global Industry Analysts, Inc. predicted the worldwide beryllium market would increase to 465 t of contained beryllium by 2015 owing to increased security concerns, which will likely increase the consumption of beryllium in defense applications. The advent of new alloys of beryllium with aluminum was also expected to contribute to the increase in beryllium consumption (Global Industry Analysts, Inc., 2011).

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TABLE 1
SALIENT BERYLLIUM MINERAL STATISTICS

(Metric tons, beryllium content)

	2006	2007	2008	2009	2010
United States, beryllium-containing ores:					
Mine shipments[1]	155	150	175	120	180
Imports for consumption, beryl[2]	--	1	--	1	5
Consumption, reported[3]	180	190	220	150	200
Stocks, December 31:					
Industry[1]	50	100	60	30	15
U.S. Government, beryl[2, 4]	9	8	(5)	(5)	(5)
World, production[e, 2]	174	174	197	144	203

[e]Estimated. -- Zero.

[1] Data are rounded to the nearest 5 metric tons.

[2] Based on a beryllium content of 4%.

[3] Data are rounded to the nearest 10 metric tons.

[4] Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center). Data for 2006 include beryl committed for sale pending shipment and uncommitted beryl. Data for 2007–10 are uncommitted beryl only.

[5] Less than ½ unit.

TABLE 2
U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE BERYLLIUM STATISTICS IN 2010[1]

(Metric tons, beryllium content)

Material	Stockpile goal[2]	Disposal authority[3]	Annual Materials Plan[4]	Uncommitted inventory, December 31
Beryl ore	--	(5)	(5) [6]	(5)
Beryllium metal:				
Hot-pressed powder	45	52	--	97 [7]
Vacuum-cast	--	14	54	14
Total	45	66	54	112
Grand total	45	66	54	112

-- Zero.

[1] Data were converted from gross weights reported in short tons; may not add to totals shown.

[2] Goal effective as of December 28, 2001.

[3] Total quantity of material that can be disposed.

[4] Maximum quantity of material that can be disposed during 12-month period ending September 30, 2010.

[5] Less than ½ unit.

[6] Actual quantity will be limited to remaining inventory.

[7] Held for goal.

Source: Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center).

TABLE 3
U.S. FOREIGN TRADE OF BERYLLIUM MATERIALS, BY TYPE[1]

Type and material	2009 Gross weight (kilograms)	2009 Content[2] (kilograms)	2009 Value (thousands)	2010 Gross weight (kilograms)	2010 Content[2] (kilograms)	2010 Value (thousands)	Principal destinations or sources, 2010[3]
Exports:							
Beryllium, unwrought[4]	5,840	5,840	$231	5,020	5,020	$215	China, 31%; Switzerland, 17%; Mexico, 16%; Thailand, 10 %.
Beryllium waste and scrap	--	--	--	527	527	48	Brazil, 36%; France, 24%; Malaysia, 17%; United Kingdom, 17%.
Beryllium, other[5]	17,000	17,000	11,500	33,100	33,100	24,100	Canada, 51%; United Kingdom, 25%.
Total	22,900	22,900	11,700	38,700	38,700	24,300	Canada, 43%; United Kingdom, 23%.
Imports for consumption:							
Beryllium ores and concentrates	18,000	720	7	113,000	4,530	68	Mozambique, 40%; Uganda, 37%; Mexico, 16%.
Beryllium oxide and hydroxide	--	--	--	83,300	30,000	548	China, 72%; France, 25%.
Beryllium, unwrought[4]	2	2	3	22,500	22,500	1,320	Russia, 89%.
Beryllium waste and scrap	6,700	6,700	161	9,240	9,240	319	Germany, 57%; Canada, 38%.
Beryllium, other[5]	5,660	5,660	833	184,000	184,000	5,150	Russia, 93%.
Beryllium-copper master alloy	205,000	8,220	2,800	323,000	12,900	6,500	Japan, 55%; Kazakhstan, 37%.
Beryllium-copper plates, sheets, and strip	165,000	2,480	1,920	508,000	7,610	6,720	Japan, 100%.
Total	401,000	23,800	5,720	1,240,000	271,000	20,600	Japan, 56%; Russia, 15%; Kazakhstan, 10%.

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Estimated from gross weights.

[3] Principal destinations or sources percentages based on beryllium content data.

[4] Includes powders.

[5] Includes articles not elsewhere specified.

Source: U.S. Census Bureau.

TABLE 4

BERYL: WORLD PRODUCTION, BY COUNTRY[1,2]

(Metric tons, gross weight)

Country[3]	2006	2007	2008	2009	2010[e]
China[e]	500	500	500	500	550
Madagascar[e,4]	12	12	12	12	12
Mozambique	16	31	8	45	45
Portugal[e]	5	5	5	5	5
United States, mine shipments[5]	3,830	3,810	4,410	3,030	4,460
Total	4,360	4,360	4,940	3,590	5,080

[e] Estimated.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 11, 2011. Unless otherwise noted, figures represent beryl ore for the production of beryllium and exclude gem-quality beryl.

[3] In addition to the countries listed, Uganda produced beryl ore. Kazakhstan, Nigeria, and Russia may also have produced beryl ore, but information is inadequate to make reliable estimates of production. Other nations that produced gemstone beryl ore may also have produced some industrial beryl ore.

[4] Includes ornamental and industrial products.

[5] Includes bertrandite ore, calculated as equivalent to beryl containing 11% beryllium oxide.

BISMUTH

By James F. Carlin, Jr.

Domestic survey data and tables were prepared by Richard H. Kraft, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Bismuth consumption in the United States was estimated to be 884 metric tons (t), 8% more than that in 2009 (tables 1, 2). The estimated value of bismuth consumed domestically was $16 million in 2010. The estimated domestic consumption breakdown for bismuth in 2010 was 65% for chemical and pharmaceutical uses, 27% for metallurgical additives for bismuth casting and galvanizing, and 8% for bismuth alloys, fusible alloys, solder, and ammunition (table 2).

Bismuth was last produced domestically as a byproduct of lead refining at a Nebraska refinery that closed in 1997. The last stocks of bismuth in the National Defense Stockpile were sold that same year. In 2010, all primary bismuth consumed in the United States was imported. Only a small amount of bismuth was obtained by recycling old scrap. The leading producers of refined bismuth in 2010 were, in descending order, China, Mexico, Belgium, and Peru. Belgium had no bismuth mine production, and its sole bismuth producer refined metal from anode slimes, concentrates, and smelter residues and flue dust, all of foreign origin. The principal suppliers to the United States were, in descending order, by weight, China, Belgium, the United Kingdom, Canada, and Kazakhstan.

In recent years, new uses for bismuth as a nontoxic replacement for lead have been developed. These include the use of bismuth in shot for water fowl hunting, lubricating greases, pigments, and solders.

The annual average dealer price for bismuth in 2010 was $8.76 per pound, an increase of 12% from that in 2009. Industry observers attributed the price increase to a lull in destocking that followed the 2008 world economic crisis.

Production

Domestic production of primary refined bismuth ceased in 1997. Some domestic firms continued to recover secondary bismuth from fusible alloy scrap in 2010. Secondary production was estimated to be less than 5% of domestic supply during 2010.

Consumption

The U.S. Geological Survey conducts a survey of domestic bismuth consumption annually. The quantity used by nonrespondents was estimated based on reports from prior use or on information from other sources. Accordingly, estimated bismuth consumption was about 884 t in 2010, an 8% increase from that in 2009.

Consumption of bismuth in chemical uses (chemicals, cosmetics, and pharmaceuticals) in 2010 remained the same as that in 2009. Consumption of bismuth for alloys increased by 12% compared with that in 2009. Metallurgical additives experienced a 5% decrease in usage compared with that in 2009. Industry observers attributed the generally lower consumption figure of recent years to the general economic slowdown, which especially affected industrial applications.

Bismuth pharmaceuticals include the well-known bismuth salicylate (the active ingredient in over-the-counter stomach remedies), and other bismuth medicinal compounds used to treat burns, intestinal disorders, and stomach ulcers in humans and animals. Bismuth nitrate was the initial material used for the production of most bismuth pharmaceutical compounds. Other applications of bismuth chemicals and compounds include uses in superconductors and pearlescent pigments for cosmetics and paints.

Bismuth metal was used primarily as a major constituent of various alloys and as a metallurgical additive (table 2). One class of bismuth alloys consists of fusible (low-melting-point, as low as 20 °C) alloys, which are combinations of bismuth with other metals, such as antimony, cadmium, gallium, indium, lead, and tin. Applications for those alloys include fuel tank safety plugs, holders for optical lens grinding, and other articles for machining or grinding, solders, and fire sprinkler triggering mechanisms.

In addition to lead-free solder noted above, bismuth has been a substitute for lead added to certain steel products to provide greater machinability. A major domestic steel producer began to use a bismuth-containing substitute for the leaded alloy about 1982. Although bismuth has been used successfully to replace lead in various applications, it has been challenged as a lead substitute by selenium and tungsten (Cusack, 1999).

Bismuth was also added in small amounts to aluminum (along with lead) and copper alloys to improve machinability. It was also added to malleable iron graphite flakes. These uses constitute the traditional metallurgical additives category.

Prices

In 2010, the annual average Platts Metals Week New York dealer price for bismuth rose to $8.76 per pound, an increase of 12% from that in 2009. In 2010, the weekly bismuth price started the year at $7.35 to $8.00 per pound and generally rose throughout the year to finish December at $9.10 to $9.60 per pound.

Foreign Trade

U.S. exports of alloys, bismuth metal, and waste and scrap increased by 77% compared with those in 2009. U.S. imports of metallic bismuth increased by 30% compared with the 2009 figures (table 4). Bismuth imports were 56% (by weight) more than bismuth exports. The leading import source for the United States was China, which supplied 54% of the total.

World Review

In much of the world, bismuth is produced as a byproduct of smelting lead ores. In China, it is also a byproduct of fluorspar, tin, and tungsten ore processing. In Bolivia, the Tasna Mine, the only mine in the world known to produce bismuth from bismuth ore, has been on standby since the mid-1990s, awaiting a rise to a sufficient and sustainable metal price.

World refinery production of bismuth was 16,000 t, a 7% increase from that in 2009. China was the world's leading producer of refined bismuth, with 81% of the world total, followed by Belgium and Mexico, each with 5%.

Canada.—MCP Group SA (Tilly, Belgium) announced it had signed a letter of intent with Fortune Minerals Ltd. (London, Ontario) to purchase bismuth from its NiCo mineral deposit in the Northwest Territories. Fortune Minerals planned to begin mining the deposit in late 2012 and expected to produce about 2,000 metric tons per year (t/yr) of bismuth, along with substantial amounts of cobalt, copper, and gold. MCP is a leading world refiner of bismuth, and it has relied on China for much of its bismuth feedstock. Development of the NiCo deposit has been challenging because of the number of regulatory issues along with indigenous tribe issues and infrastructure requirements. If the project does come to fruition, it would add a significant amount of bismuth to the world market, which was estimated to be about 10,000 t/yr (Ryan's Notes, 2010).

China.—Minmetals Corp. (Beijing) announced plans to spend $658 million to $804 million in a 5-year period to explore for bismuth, rare earths, tin, and tungsten in southern Hunan Province. Minmetals signed a strategic cooperation deal with the Chenzhou City government (American Metal Market, 2010).

Outlook

During much of the past decade, worldwide bismuth consumption has been increasing at about 3% to 5% per year. However, the global economic slowdown that began in late 2008 and extended through the first half of 2009 led to a substantial contraction in consumption. World consumption of bismuth in the steel sector decreased, although it was relatively minor compared with that in other use sectors. World consumption in the chemical industry seemed to be rising, especially in Japan, as bismuth began to replace lead in pigments.

Selected segments of the bismuth use markets, such as metallurgical additives in particular, were very much involved in the industrial sectors of the economy, and any improvement there will likely depend on how quickly the world's industrialized nations can rebound from the 2008–09 economic slowdown.

Commercial and research organizations in Europe, Japan, and North America agreed to a framework to eliminate lead from solders in manufacturing. This agreement would tend to increase the demand for bismuth because bismuth is used in some solders. Many Japanese manufacturers were using lead-free solders in some or all of their soldering applications, and studies on how best to develop lead-free solders were being performed independently by the European Union, Japan, the Republic of Korea, and the United States. Although world lead consumption was expected to be reduced by only 0.8% by the elimination in solder, replacement of lead could increase world bismuth consumption by about 25%.

A significant near-term increase in supplies of lead byproduct seemed unlikely because world production of lead from mine sources was expected to be relatively stable, and an increasing portion of lead demand was expected to be met by recycling. A global shortage of bismuth, however, was not anticipated. In China, new technologies have increased world bismuth reserves. Therefore, despite increases in world demand, supplies from China can be expected to help keep the bismuth market stable, unless China decides to restrict bismuth exports as it has done for some other metals.

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TABLE 1
SALIENT BISMUTH STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Consumption[e, 2]	metric tons	1,960	2,630	1,090	820 [r]	884
Exports[3]	do.	311	421	375	397	704 [4]
Imports for consumption	do.	2,300	3,070	1,930	1,250	1,620
Price, average, domestic dealer	dollars per pound	5.04	14.07	12.73	7.84	8.76
Stocks, December 31, consumer	metric tons	120	139	228	134	134
World production:[e, 5]						
Mine, metal content[6]	do.	5,800	6,200	7,600	8,300 [r]	8,900
Refinery	do.	15,000	16,000	17,000 [r]	15,000	16,000

[e]Estimated. [r]Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits.

[2] Estimated based on net imports.

[3] Comprises bismuth metal and the bismuth content of alloys and waste and scrap.

[4] Source: U.S. Census Bureau; data as adjusted by U.S. Geological Survey.

[5] Data are rounded to no more than two significant digits.

[6] Excludes the United States.

TABLE 2
ESTIMATED BISMUTH METAL CONSUMED IN THE UNITED STATES, BY USE[1, 2]

(Metric tons)

Use	2009 [r]	2010
Chemicals[3]	528	589
Bismuth alloys	58	62
Metallurgical additives	232	231
Other	2	4
Total	820	884

[r]Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Estimated based on net imports.

[3] Includes industrial and laboratory chemicals, cosmetics, and pharmaceuticals.

TABLE 3
U.S. EXPORTS OF BISMUTH METAL, ALLOYS, AND WASTE AND SCRAP, BY COUNTRY[1]

	2009		2010	
Country	Quantity (kilograms, metal content)	Value (thousands)	Quantity (kilograms, metal content)	Value (thousands)
Argentina	220	$17	391	$19
Australia	--	--	934	11
Austria	--	--	20,000	190
Belgium	56,600	820	14,800	255
Brazil	13,400	121	10,600	96
Canada	32,900	701	41,400	947
China	28,800	261	26,400	240
Colombia	1,230	29	743	27
Costa Rica	--	--	12,500	130
Dominican Republic	6,550	60	--	--
France	121,000	1,450	286,000 [2]	2,840 [2]
Germany	2,420	37	73,500	668
Guatemala	--	--	1,090	7
Hong Kong	2,410	26	9,260	84
India	121	3	644	8
Japan	11,000	309	4,160	106
Mexico	59,300	1,350	100,000	1,160
Singapore	445	30	2,060	54
Taiwan	219	16	526	13
Thailand	8,590	78	21,700	200
United Kingdom	4,710	50	1,320	29
Vietnam	45,200	411	75,100 [2]	986 [2]
Other	1,570	56	483	62
Total	397,000	5,820	704,000 [2]	8,140 [2]

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Source: U.S. Census Bureau; data as adjusted by U.S. Geological Survey.

Source: U.S. Census Bureau.

TABLE 4

U.S. IMPORTS FOR CONSUMPTION OF METALLIC BISMUTH, BY COUNTRY[1]

	2009		2010	
Country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Belgium	450,000	$8,350	674,000	$12,900
Canada	5,740	88	21,300	339
China	554,000	8,180	875,000	15,400
Germany	1,600	94	4,090	205
Hong Kong	--	--	297	2
Italy	50	8	200	45
Japan	--	--	3	4
Kazakhstan	9,850	185	10,000	195
Korea, Republic of	75,100	1,170	40	3
Mexico	59,400	758	373	75
Netherlands	124	22	15	3
Peru	29,400	386	455	8
Russia	3,320	239	499	65
United Kingdom	62,400	1,110	35,800	761
Total	1,250,000	20,600	1,620,000	30,100

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5

BISMUTH: ESTIMATED WORLD MINE AND REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

	Mine					Refinery				
Country	2006	2007	2008	2009	2010	2006	2007	2008	2009	2010
Belgium	--	--	--	--	--	800	800	800	800	800
Bolivia	155[3]	147[3]	28[3]	54[r, 3]	87[3]	1[3]	--[3]	92[3]	73[r, 3]	--
Bulgaria	45	45	45	45[r]	45	30	30	30	30[r]	30
Canada[4]	177[3]	137[3]	71	86[3]	91	250	200	150	150[3]	150
China	3,000	3,500	5,000	6,000	6,500	11,800	12,100	13,100[r]	12,300[r]	13,000
Italy	--	--	--	--	--	5	5	5	5	5
Japan[5]	21	20	20	21	20	425[3]	408	480[r]	423[r]	420
Kazakhstan	140	145	150	150	150	115	120	125	125	125
Mexico	1,186[3]	1,200	1,170	854	850	1,186[3]	1,200	1,170	854	850
Peru	950	950	960	1,000[r]	1,100	600	600	600	600	600
Romania	40	40	40	40	40	30	30	30	30[r]	30
Russia	55	55	70	65	50	11	12	13	12	10
Total[6]	5,800	6,200	7,600	8,300[r]	8,900	15,000	16,000	17,000[r]	15,000	16,000

[r] Revised. -- Zero.

[1] Estimated data are rounded to no more than three significant digits.

[2] Table includes data available through April 20, 2011. Bismuth is produced primarily as a byproduct of other metals, mainly lead and tungsten.

[3] Reported figure.

[4] Figures listed under mine output are the metal content of concentrates produced, according to Natural Resources Canada, 2006.

[5] Mine output figures have been estimated to be 5% of reported metal output figures.

[6] World totals are rounded to no more than two significant digits.

BORON

By Marc A. Angulo and Robert D. Crangle, Jr.

Domestic survey data and tables were prepared by Shonta E. Osborne, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

U.S. consumption of minerals and compounds reported in boron oxide continued to increase in 2010 but quantities are withheld to avoid disclosing company proprietary data (table 1). Turkey and the United States were the world's leading producers of boron minerals (table 6). World production of boron minerals increased in 2010 to an estimated 4.08 million metric tons (Mt) compared with 3.76 Mt in 2009 (excluding U.S. production). The United States exported 264,000 metric tons (t) of boric acid and 423,000 t of sodium borate in 2010, an increase from the 171,000 t of boric acid and 417,000 t of sodium borates exported in 2009 (tables 1, 4). Boron imports consisted primarily of borax, boric acid, colemanite, and ulexite (tables 1, 5).

Elemental boron is a metalloid with limited commercial applications. The main applications were as a doping agent in the manufacture of semiconductors and as an ignition source in airbags. The global consumption rate of elemental boron was estimated to be 15 metric tons per year (t/yr). Boron compounds, chiefly borates, are commercially important; therefore, boron products are priced and sold based on boric oxide content (B_2O_3), which varies by ore and compound, and on the absence or presence of sodium and calcium (table 2). Borax, one of the most important boron minerals for industrial use, is a white crystalline substance chemically known as sodium tetraborate decahydrate and is found in nature as the mineral tincal. Boric acid, also known as orthoboric acid or boracic acid, is a white, colorless crystalline solid sold in technical, national formulary, and special quality grades as granules or powder. Colemanite (hydrated calcium borate), kernite (hydrated sodium borate), tincal, and ulexite (hydrated sodium calcium borate) were the minerals of most commercial importance in the United States (table 2).

Production

Four minerals make up 90% of the borates used by industry worldwide: the sodium borates tincal and kernite, the calcium borate colemanite, and the sodium-calcium borate ulexite. Borate deposits are associated with volcanic activity and arid climates, and the largest borate deposits are located in the Mojave Desert of the United States, the Alpide belt in southern Asia, and the Andean belt of South America. As a result, most borates were extracted primarily in California and Turkey and to a lesser extent in Argentina, Bolivia, Chile, China, and Peru. Boron compounds and minerals were produced by surface and underground mining and from brine.

Domestic data for boron were derived by the U.S. Geological Survey from a voluntary survey of two U.S. producers—Rio Tinto Group's U.S. Borax Inc. and Searles Valley Minerals, Inc. (SVM). Both companies responded; however, data were withheld to avoid disclosing company proprietary data (table 1).

SVM, acquired by the Indian company Nirma in 2007, produced borax and boric acid from brines containing potassium and sodium borates that were extracted from three salt layers, up to 100 meters (m) deep, in Searles Lake, located near Trona in San Bernardino County, CA. SVM's Trona and Westend plants refined the brines, producing anhydrous, decahydrate, and pentahydrous borax. These brines also supplied other commercial salts in addition to sodium borates and boric acid. The Trona plant has a reported capacity of 27,500 t/yr B_2O_3, and the Westend plant has a reported capacity of 82,300 t/yr B_2O_3.

Rio Tinto Borax (a wholly owned subsidiary of United Kingdom-based Rio Tinto Minerals) mined mainly tincal and kernite at Boron, CA, by open pit methods, and the ore was transported by truck to a storage area. The tincal had an average grade of 25.3% B_2O_3 and the kernite had an average grade of 31.9% B_2O_3. Boric acid and refined sodium borates were produced at an onsite processing plant. Refined borate products were shipped by railcar or truck to North American customers or to the company's Wilmington, CA, facility and exported from the Port of Los Angeles. Specialty borate products were made at the Wilmington plant. According to a Securities and Exchange Commission report filed by Rio Tinto Borax, the company produced 483,000 t of borates in 2010, an 18% increase from the 411,000 t reported in 2009 (Rio Tinto plc, 2011, p. 80).

As part of a divestment program in September 2007, Rio Tinto Minerals put Rio Tinto Borax on sale. In July 2009, the company canceled the sale because bidders had not offered the valuation of the asset (Industrial Minerals, 2009c). In May, a labor agreement reached by Rio Tinto Borax and the employees' labor union, International Longshore & Warehouse Union, effectively ended a 3-month strike at the borate mine in Boron. During the strike, operations were manned by temporary employees and 170 unaffected worked (Watts, 2010). In January 2011, Rio Tinto declared force majeure on sales of its sodium borate products owing to disruptions at its Boron Mine in Boron, CA, caused by heavy rain storms in late December 2010. Although 2010 production from Rio Tinto's California and Argentina mines increased by 18% from that of 2009, production during the fourth quarter 2010 decreased by 20% from that of the third quarter 2010 (O'Driscoll, 2011b).

Consumption

The first reported use of borax was as a flux or bonding agent by Arabian gold and silversmiths in the eighth century, but current research suggests Babylonians may have used it 4,000 years ago. Today, there are more than 300 end uses for borates, but more than three-quarters of the world's supply is sold and distributed for five end uses (Garrett, 1998; Hamilton, 2006).

In 2010, U.S. imports for consumption of borax, boric acid, colemanite, and ulexite were 101,000 t, a 5% increase from 96,000 t imported in 2009. In 2010, total U.S. apparent consumption of all boron products increased by 6% compared with that of 2009.

Agriculture.—Fertilizers represented the third largest application of borates. Boron was the most widely used micronutrient, applied primarily to promote fruit and seed production. Boron fertilizers were mostly sourced from borax, boric acid, and calcium borate owing to their high water solubility; thus, boron fertilizers can be delivered through sprays or irrigation water. Domestic consumption of boron fertilizers was estimated to be approximately 2% of total U.S. fertilizer consumption.

Boron is essential for plant uptake of primary and secondary nutrients, such as calcium, manganese, magnesium, phosphorus, and zinc. It influences the transport of nutrients through plant membranes, which directly correlates into improved fruit development, germination, plant reproduction, and pollen production. Normal plant leaves typically contain 25 to 100 parts per million of boron, with 1 kilogram per hectare of boron (1 pound per acre) in soil being adequate to maintain these levels. U.S. boron deficiencies in crops are found primarily in the Atlantic coastal plains, Great Lakes region, and the coastal Pacific Northwest, where soils tend to be acidic, leached, coarse sandy, or organic in nature. Excessive boron fertilization, on the other hand, can cause crop toxicity, which studies suggested was more often caused by higher boron levels in irrigation water than those in soil (Troeh and Thompson, 2005, p. 489).

Ceramics.—Ceramics comprise the second largest application of borates after glass, accounting for 10% of world consumption. Borates play an important role in ceramic glazes and enamels, increasing chemical, thermal, and wear resistance. Borax and colemanite are used in ceramics primarily as fluxing agents, with borax being used in higher temperature, and colemanite in lower temperature firings. Borates are also used in technical ceramics, an industry with applications in aerospace, ballistics, electronics, and medicine, which experienced strong growth during the past decade. The amount of B_2O_3 used in glazes varies between 8% and 24% and the amount used in enamels is between 17% and 32% by weight.

Boron carbide is a key ingredient in lightweight ceramic armor, the use of which created increased United States and European consumption of boron carbide during the past few years. Small arms protective inserts, used by the U.S. military, are boron carbide ceramic plates inserted into Kevlar flak jackets to protect against high-velocity projectiles (Industrial Minerals, 2008b).

A new calcined borate, known as E4972, was developed to replace conventional frits used in ceramic glazes. Frits were incorporated into glazes to obtain the appropriate technical and aesthetic properties under short firing of ceramics. E4972 possesses a low solubility, which enables its use in glaze formation (Industrial Minerals, 2009a).

Detergents and Soaps.—The use of borates in detergents and soaps represented the fourth largest market, accounting for 4% of world consumption. Borates were incorporated into laundry detergents, soaps, and other cleaning products because they can be used as alkaline buffers, enzyme stabilizers, oxygen-based bleaching agents, and water softeners. Two borates, sodium perborate and perborate tetrahydrate, were used as oxidizing bleaching agents because they contain true peroxygen bonds. Hydrogen peroxide, a very effective bleaching agent, is produced when sodium perborate undergoes hydrolysis while in contact with water. Because hydrogen peroxide cannot be effectively incorporated into detergents, sodium perborate acts as its carrier (Rio Tinto Borax, 2005). Sodium perborate, however, requires hot water to undergo hydrolysis, and concerns have emerged over excessive boron levels in waterways owing to sodium perborate in detergents. Sodium percarbonate has been used as a substitute primarily in Europe because it produces hydrogen peroxide at lower temperatures. This substitution has affected boron consumption.

Ferroboron.—Ferroboron (FeB) is a binary alloy of iron with a boron content between 17.5% and 24% and is the lowest cost boron additive for steel and other ferrous metals. On average, the steel industry consumes more than 50% of the ferroboron produced annually (Eti Holding Inc., 2003, p. 8). Boron steel, containing nearly 0.008% ferroboron, possesses a higher strength and lighter weight than that of average high-strength steel, and is a useful material in the manufacturing of safe and fuel efficient automobiles.

Ferroboron was used in the production of cast iron, neodymium-iron-boron (Nd-Fe-B) magnets, and steel. Nd-Fe-B magnets consumed nearly 10% of the ferroboron produced annually (Eti Holding Inc., 2003, p. 8). Nd-Fe-B magnets possess the highest strength of all magnets and were used in computer hard drives, guidance systems, and wind turbines (Moores, 2010). Ferroboron was also utilized in aluminum castings to refine grain-size; in copper-base alloys and high-conductance copper as a degasifier; and in the nonferrous metals industry, generally as a deoxidizer.

Fire Retardants.—Borates were incorporated into various materials, such as cellulosic insulation, textiles, and timber, to impart flame retardant properties to the materials. Boric acid was incorporated into wood flame-retardants to inhibit the transfer of combustible vapors and reduce the effective heat of combustion, resulting in reduced flame spread. Zinc borate was used in plastics as a multifunctional boron-based fire retardant, with applications in a variety of plastics and rubber compounds. Zinc borate is mainly used in flexible and rigid polyvinyl chloride formulations partly substituting for antimony trioxide. It is increasingly used as a component of halogenated and halogen-free formulations in epoxies, nylons, polyolefins, rubber, and thermoplastic polyesters.

Glass.—The principle market for borates in 2010 was glass, representing approximately 60% of global borate consumption. Boron is used as an additive in glass to reduce thermal expansion, improve strength, chemical resistance, and durability, and provide resistance against vibration, high temperature, and thermal shock. Boron is also used as a fluxing agent, reducing the viscosity of glass during formation to improve manufacturing. Depending on the application and quality of the glass, borax, boric acid, colemanite, ulexite, and sodium borates are typically used.

Insulation and textile fiberglass represented the largest single use of borates worldwide, at 45% of world consumption. End uses for fiberglass are corrosion-resistant, heat-resistant, and high-strength fabrics; insulation; reinforcement; and sound absorption. The incorporation of borates into fiberglass greatly improves quality, establishing a product that is strong, lightweight, and thermal and chemical resistant (Garrett, 1998).

Borosilicate refers to glass with boric oxide content between 5% and 30%. The boron in borosilicate imparts many valuable properties to the glass, such as increased mechanical strength, low coefficient of thermal expansion, and resistance to chemical attack and thermal shock. Past application of borosilicate ranged from Pyrex® kitchenware to the thermal protection tiles on the National Aeronautics and Space Administration Space Shuttle Orbiter.

Other.—Boron fiber is a monofilament about 125 to 140 nanometers in diameter comprising elemental boron, typically produced under chemical vapor deposition of boron trichloride with tungsten wire acting as the catalyst. Owing to its high strength and hardness, boron fiber was used in the construction of the horizontal and vertical stabilizers and rudders of the F-14 and F-15 fighter and B-1 bomber aircrafts. The lower production cost and the higher availability associated with carbon fiber has limited boron fiber's use in modern aviation structural components. However, boron fiber has proven to be more advantageous than carbon fibers when used as a repair material for structural defects (Baker and others, 2004, p. 249).

Various boron compounds are used in nuclear powerplants to control neutrons produced during nuclear fission. The isotope boron-10, in particular, possesses a high propensity for absorbing free neutrons, producing molecules of lithium and alpha particles after absorbing neutrons. Control rods composed of boron carbide are lowered into a nuclear reactor to control the fission reaction by capturing neutrons. Boric acid is used in the cooling water surrounding nuclear reactors to absorb escaping neutrons (Ceradyne Inc., 2011).

Borazine and polyborazylene can be used as precursor chemicals to boron nitride coatings and composites. Boron nitride can also be found in large quantities in cosmetics owing to its low coefficient of friction and lack of toxicity. It has been shown to be a useful alternative to talcum powder, which studies show may be linked to ovarian cancer (Emsley, 2004, p. 15–17). Boric acid has applications in cosmetics, pharmaceuticals, and toiletries. Borates are also added to brake fluids, fuel additives, lubricants, metalworking fluids, and water treatment chemicals. Boron oxide inhibits corrosion.

Transportation and Distribution

Almost all U.S. borates were shipped in North America by rail. Both U.S. producers had rail fleets dedicated to the exclusive transportation of their products. Small shipments of borates were shipped by rail or truck in specialty bags, usually of 2,100-pound capacity. Prices for rail haulage depended on the ability of customers to load and unload efficiently, the ability to use unit trains and to supply one's own railcars, and fuel prices.

SVM owned the Trona Railway, a 50-kilometer (km) (31-mile) shortline railroad that connects to the Southern Pacific Railroad between Trona and Searles stations in California. The Trona Railway provided a dedicated line with access to the national rail system for the borate, soda ash, and sodium sulfate markets. Nearly 80% of output was transported by rail to domestic consumers and to the ports of Long Beach and San Diego in California for export.

The Boron Mine was served solely by the Burlington Northern Santa Fe Railroad. In order to connect to another rail line, a transload or transfer point was set up in Cantil, CA, served by the Union Pacific Railroad. Trucks of product from Boron were driven to Cantil, about 64 km (40 miles) northwest of Boron and loaded into dedicated railcars to be shipped to customers.

Rio Tinto Borax utilized a privately owned berth located in the Port of Los Angeles, CA, for ocean transportation of borate products. Products destined for Europe were shipped from the bulk terminal in Wilmington to a company-owned facility in the Port of Rotterdam, Netherlands, company facilities in Spain, or contracted warehouses. The most centrally located Rio Tinto Borax port location in Europe was Antwerp, Belgium. The industrial minerals market in Europe was characterized by high volumes of imported materials, mostly forwarded through the industrialized areas of Belgium, France, Germany, and the Netherlands for destinations in Central Europe, including Austria, the Czech Republic, and Slovenia. A decision to import borates was based on the geographic location, the range of borate products needed, and prices.

Rio Tinto Borax used barges to ship borates from Rotterdam to customers in Belgium, Eastern Europe, France, and Germany. Barges were the most efficient and reliable mode of transportation throughout Europe because waterways provide an ideal, low-cost linkage between large industrial areas and the Baltic, Black, Mediterranean, and North Seas and the Atlantic Ocean.

More than 65% of boric acid and sodium borate imports entered the United States through the ports of Norfolk, VA, and Philadelphia, PA. More than 87% of total exports of boron compounds and minerals left the United States through the ports of Los Angeles, CA, and Houston-Galveston, TX.

Prices

Yearend prices of boron minerals and compounds produced in the United States are listed in table 3. Prices for borates remained relatively unchanged from 2009 to 2010. The decrease in price observed from 2008 to 2009 reflected an imbalance between supply and demand created by the economic downturn observed beginning in the fourth quarter of 2008. The stabilization of prices from 2009 to 2010 may be an indicator that equilibrium between supply and demand was obtained during this period. Table 4 lists the free alongside ship values for U.S exports of boric acid and quantities of boric acid and refined sodium borate compounds exported to various countries.

Foreign Trade

The United States remained a net exporter of boron compounds and minerals in 2010, with net exports totaling 592,000 t, a 19% increase from the 498,000 t in 2009. Exports of boron compounds and minerals increased by 17% to 687,000 t in 2010. In 2010, China received the largest amount of sodium borates and boric acid from the United States owing to increased consumption of borates used in the Chinese glass and ceramic industries. Imports of 101,000 t in 2010 was a 6.3% increase from that of 2009. The sharp decrease in imports of ulexite in 2010 is primarily attributed to a 27,000 t decrease in shipments from Turkey.

World Review

Argentina.—Argentina became the leading producer of boron minerals in South America in 2010 (table 6). Borate deposits are located primarily in the Puna region, which includes the northwestern tip of Argentina, the southeastern corner of Peru, the southwestern corner of Bolivia, and the northeastern border of Chile. Recent increased demand in Asia and North America for borate use in ceramics and glass led to increased production of Argentine borates, boric acid in particular.

Borax Argentina S.A. (a subsidiary of Rio Tinto Minerals), the country's leading producer of borates, operated open pit mines at Porvenir in Jujuy Province and at Sijes and Tincalayu in Salta Province. These operations produced colemanite, hydroborocite, kernite, tincal, and ulexite at a rate of 100,000 t/yr (Industrial Minerals, 2009b). Located at 4,100 m (13,400 feet) above sea level, the Tincalayu Mine was Argentina's largest open pit operation. The deposit consisted primarily of borax, with rare occurrences of ulexite and 15 other borates. Rio Tinto also produced refined borate ores and boric acid at refineries in Campo Quijano, Sijes, and Tincalayu in Salta Province and Porvenir in Jujuy Province. Lithium Americas Corp. entered into an agreement with Borax Argentina to extract subsurface lithium and borate brines from the salt lake at Jujuy Province. The company contends that the brine has the correct composition to be economically viable (Industrial Minerals, 2009e). The company produced 18,000 t of borates in 2010, a 38% increase from the 13,000 t reported in 2009 but a 5% decrease from the 19,000 t produced in 2008 (Rio Tinto plc, 2011, p. 80).

Minera Santa Rita S.R.L. (MSR) operated mines in Catamarca, Jujuy, and Salta Provinces and operated a processing plant in Campo Quijano, which produced granular deca- and pentahydrate borax, technical-grade boric acid powder, and various grades and sizes of the natural boron minerals. MSR exports 97% of its products to 28 countries through the port of Buenos Aires and by land to Brazil. MSR refined more than 50,000 t/yr of borates and was expected to refine 75,000 t/yr after the investment in a "flowing bed" system, a device that more efficiently dries boric acid. MSR has also announced a permanent supply agreement with Sulphaar S.R.L. to furnish sulfuric acid for the Campo Quijano plant (Santa Rita Mining Co., 2011).

Bolivia.—The most important Bolivian borate deposits, mined primarily by small cooperatives, are located in the Altiplano of the Andes and contain ulexite with associated tincal. The Bolivian mining agency, Corporación Minera de Bolivia (COMIBOL), was seeking to develop the Salar de Uyuni salt flats for future borate production. COMIBOL planned to establish a $5 million borate pilot plant on the deposit to determine full-scale feasibility. A full-scale boric acid plant would be expected to produce 20,000 t/yr (Industrial Minerals, 2006, 2009c; Moores, 2009).

Chile.—In 2010, Chile was the second leading producer of boron minerals in South America (table 6). The 504,000 t of boron minerals produced in 2010 was a 17% decrease from that of 2009. The Chilean borate producers were all located on the northeastern border of Chile, which contains one the world's largest deposits of ulexite. The largest producer, Quimica e Industrial del Borax Ltda. (Quiborax), mined 450,000 t/yr of crude ulexite and produced up to 80,000 t/yr of boric acid and 40,000 t/yr of granular ulexite (Tran, 2008).

China.—China possessed more than 100 borate deposits in 14 Provinces. The northeastern Province of Liaoning and the western Province of Qinghai accounted for more than 80% of the resources, mostly in the form of sassolite and tincal. Chinese boron resources are of low quality, averaging about 8.4% B_2O_3, in comparison to the Turkish and United States reserves, which average about 26% to 31% and 25.3% to 31.9% B_2O_3, respectively. Apparent consumption of borate in China increased by 7% per year between 2000 and 2009 fueled by the glass and ceramic industries, but domestic production remained relatively consistent during this period. To maintain this high level of consumption and moderate level of production, China became more import reliant on borate products originating from Russia, South America, Turkey, and the United States (Industrial Minerals, 2008a; Baylis, 2010, p. 5).

The Chinese government was considering closing a loophole that gives a 5% tax rebate on the export of alloys in attempts to curtail misuse of the rebate. Some carbon steel mills added small amounts of boron, nearly 0.0005% by weight, to pass the steel off as an alloy in order to collect the rebate. This practice may have given these mills as much as a 20% pricing advantage on their products (Metal Bulletin, 2011).

India.—Although deposits of borates were identified in India, the country was reliant on imports of borates from China, Turkey, and the United States to fulfill domestic needs. Borate products produced in India include boric acid, boron carbide, ferroboron, and sodium perborate. The leading producer of refined borates was Indo Borax & Chemical Ltd., which operated borax and boric acid plants in Pithampur, Madhya Pradesh, northeast of Mumbai.

Serbia.—Erin Ventures Inc. (Victoria, British Columbia, Canada) entered into a binding agreement with the Serbian state-owned coal mining company, JP PEU, for joint development of the Piskanja borate deposit in southern Serbia. Additionally, Erin Ventures was seeking monetary compensation totaling $15 million from Elektroprevreda, the Serbian national power corporation, over an alleged 1997 breach of contract in the development of the Piskanja deposit. The deposit had an estimated resource of 7.5 Mt averaging 36% to 39% B_2O_3 (O'Driscoll, 2010, 2011a).

Rio Tinto Minerals held a license to the Jadar borate lithium deposit 150 km north of the Piskanja deposit and planned further exploration drilling in 2010. Initial drilling revealed an inferred resource of 114 Mt with a 13.1% B_2O_3 and 1.8% Li_2O grade. The company expected to produce borate by 2015 (Industrial Minerals, 2009d; O'Driscoll, 2010, 2011a).

Turkey.—The main borate producing areas of Turkey, all controlled by the state-owned mining company Eti Maden AS, are Bigadic (colemanite and ulexite), Emet (colemanite), Kestelek (colemanite, probertite, and ulexite), and Kirka (tincal). Production of refined borates increased during the past few years owing to continued investment in new refineries and technologies. Eti Maden planned to expand its share in the world boron market from 36% to 39% by 2013, increasing sales to $1 billion by expanding its production facilities and product range. In 2009, Turkey exported 4 Mt of borates valued at $104 million (Today's Zaman, 2009; Uyanik, 2010).

Since 2007, the Turkish government has granted 110 million Turkish lira (about $64 million) to 317 proposals in support of the Industry-University Project (SAN-TEZ). SAN-TEZ was implemented to develop boron-related technologies that might lead to increased consumption of Turkish borates (Today's Zaman, 2010).

Outlook

Consumption of borates is expected to increase, spurred by strong demand in the Asian and South American agriculture, ceramic, and glass markets. World consumption of borates was projected to reach 2.0 Mt B_2O_3 by 2014, compared with 1.5 Mt B_2O_3 in 2010 (Roskill Information Services Ltd., 2010, p. 167; O'Driscoll, 2011a).

Europe and emerging markets are requiring higher building standards, correlating to increased consumption of insulation fiberglass. Domestic demand for fiberglass was dominated by the construction industry, which saw decreased U.S. activity in 2009 owing to the global economic downturn. With a projected sluggish economic recovery in the construction industry, demand for fiberglass, which increased at a rate of 5% annually between 2000 and 2008, was expected to continue to increase but at a slower rate (Roskill Information Services Ltd., 2010, p. 179). Demand for boron based fertilizers was expected to rise owing to increased demand for food and biofuel crops. Higher crop prices have enabled farmers to invest more capital in advanced farming techniques and higher-grade fertilizers. Consumption of borates by the ceramics industry was expected to shift away from Europe to Asia, which accounted for 60% of world demand in 2010.

Research into boron use in nanotechnology is progressing rapidly. More stable forms of boron nanotubes have been constructed, and more efficient fabrication techniques have been developed. In 2009, a team of material scientists created the first high-quality, uniformly crystalline boron nitride nanotubes in large quantities (EurekAlert, 2010). The first successful measurement of the strength of boron nitride nanotubes was performed in 2010, adding to high expectations for potential applications (Nanowerk, 2010). Boron nanotubes were expected to overtake carbon nanotubes as the ideal material in nanoengineering because boron nanotubes can be configured as electrical conductors, a property not inherent to carbon nanotubes (Battersby, 2008; Oku, 2008).

The use of boron nitrate in neutron-emitting nuclear material detectors may increase owing to scientific advances. Conventional neutron-emitting nuclear material detectors use helium-3 gas to detect neutrons emitted from nuclear reactive material. The problem with these detectors lies in their large irregular size and the decreasing supply of helium-3. Detectors using boron nitrate are smaller in size, and availability of boron nitrate is greater (Jean, 2010).

Consumption of boron nitride is expected to increase owing to the development of high-volume production techniques coupled with the creation of new technologies. The properties intrinsic to cubic boron nitride, such as hardness (second only to diamond), high thermal conductivity, and oxidation resistance make it an ideal material in a variety of emerging applications. Hexagonal boron nitride was used in additives, ceramics, and intermetallic composites, imparting thermal shock resistance, improved machinability, and reduction of friction. Pyrolytic boron nitride is finding rapid acceptance in molecular beam epitaxy crucibles and furnace hardware owing to its high tensile strength and its anisotropic nature (Lelonis, 2007).

The European Chemical Agency has declared the use of boric acid in the development of photographs to pose no health risk to consumers with the proper handling of the chemicals. This ruling was considered to have wider implications for the use of borates used in other applications, such as in the ceramic and glass industries (Industrial Minerals, 2010a).

Chinese Nd-Fe-B magnet production is expected to increase 25% per year through 2014, driven by an increase in high-technology applications. With boron content in Nd-Fe-B magnets averaging 18% to 22%, the Chinese boron industry was investigating ways to expand the use of boron from its low-grade deposits through more efficient and effective processes (Industrial Minerals, 2010b).

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TABLE 1

SALIENT STATISTICS OF BORON MINERALS AND COMPOUNDS[1]

(Thousand metric tons and thousand dollars)

	2006	2007	2008	2009	2010
United States:					
Sold or used by producers:					
Quantity:					
Gross weight[2]	W	W	W	W	W
B_2O_3 content	W	W	W	W	W
Value	W	W	W	W	W
Exports:[3]					
Boric acid:[4]					
Quantity	221	248	303	171	264
Value	126,000	124,000	165,000	109,000	170,000
Sodium borates:					
Quantity	393	446	519	417	423
Value	138,000	146,000	192,000	176,000	218,000
Imports for consumption:					
Borax:[3]					
Quantity	2	1	1	(5)	(5)
Value	701	647	566	376	183
Boric acid:[3]					
Quantity	85	67	50	36	50
Value	34,900	27,500	26,200	26,100	30,100
Colemanite:					
Quantity[6]	25	26	30	31	50
Value	7,260	7,640	8,880	8,630	18,400
Ulexite:					
Quantity[6]	131	92	75	28	1
Value	39,200	27,600	22,600	11,300	238
Consumption, B_2O_3 content	W	W	W	W	W
World, production[7]	3,620 [r]	4,200	4,480 [r]	3,760 [r]	4,080 [e]

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Minerals and compounds sold or used by producers, including actual mine production, and marketable products.

[3] Source: U.S. Census Bureau.

[4] Includes orthoboric and anhydrous boric acid. Harmonized Tariff Schedule of the United States codes 2840.19.0000, 2840.20.0000, and 2840.30.0000.

[5] Less than ½ unit.

[6] Source: Journal of Commerce Port Import/Export Reporting Service.

[7] U.S. production withheld from world production in 2006–10 to avoid disclosing company proprietary data.

TABLE 2
BORON MINERALS OF COMMERCIAL IMPORTANCE

Mineral[1]	Chemical composition	B_2O_3, weight percentage
Boracite (stassfurite)	$Mg_3B_7O_{13}Cl$	62.2
Colemanite	$Ca_2B_6O_{11}\cdot 5H_2O$	50.8
Datolite	$CaBSiO_4OH$	24.9
Hydroboracite	$CaMgB_6O_{11}\cdot 6H_2O$	50.5
Kernite (rasortie)	$Na_2B_4O_7\cdot 4H_2O$	51.0
Priceite (pandermite)	$CaB_{10}O_{19}\cdot 7H_2O$	49.8
Probertite (kramerite)	$NaCaB_3O_9\cdot 5H_2O$	49.6
Sassolite (natural boric acid)	H_3BO_3	56.3
Szaibelyite (ascharite)	$MgBO_2OH$	41.4
Tincal (natural borax)	$Na_2B_4O_7\cdot 10H_2O$	36.5
Tincalconite (mohavite)	$Na_2B_4O_7\cdot 5H_2O$	47.8
Ulexite (boronatrocalcite)	$NaCaB_5O_9\cdot 8H_2O$	43.0

[1] Parentheses indicate common names.

TABLE 3
YEAREND PRICES FOR BORON MINERALS AND COMPOUNDS[1]

(Dollars per metric ton)

Product	Price, December 31, 2008	Price, December 31, 2009	Price, December 31, 2010
Borax, decahydrate, Buenos Aires	560	520	520
Boric acid, Chile	950	800	735
Colemanite, Buenos Aires, 40% boron oxide (B_2O_3)	420–460	370–420	370–420
Ulexite, Buenos Aires, 40% B_2O_3	390–410	350–380	350–380
Ulexite, granular, Chile, 40% B_2O_3	500	400	400
Ulexite, Lima, 40% B_2O_3	490–520	250–300	350–370

[1] U.S. free on board plant or port prices per metric ton of product. Other conditions of final preparation, transportation, quantities, and qualities not stated are subject to negotiation and (or) somewhat different price quotations. Values have been rounded to the nearest dollar.

Source: Industrial Minerals, no. 495, December 2008, p. 88; no. 507, December 2009, p. 68; no. 519, December 2010, p. 69.

TABLE 4
U.S. EXPORTS OF BORIC ACID AND REFINED SODIUM BORATE COMPOUNDS, BY COUNTRY[1]

	2009			2010		
	Boric acid[2]		Sodium	Boric acid[2]		Sodium
Country	Quantity (metric tons)	Value[3] (thousands)	borates[4] (metric tons)	Quantity (metric tons)	Value[3] (thousands)	borates[4] (metric tons)
Australia	3,990	$2,550	9,310	1,780	$1,120	4,330
Belgium	132	172	259	3	11	14
Brazil	448	613	3,300	1,190	1,550	927
Canada	2,970	2,440	27,500	2,530	2,290	27,500
China	26,500	14,500	146,000	59,900	35,000	104,000
Colombia	190	250	3,990	159	210	6,840
France	4,280	5,270	312	120	81	324
Germany	316	532	1	1,380	1,670	1
Hong Kong	--	--	4	--	--	--
India	1,530	1,200	17,400	3,930	2,840	32,300
Indonesia	833	532	4,770	1,340	935	9,630
Italy	--	--	2,400	93	94	1,080
Japan	22,800	16,700	19,500	46,100	32,500	25,300
Korea, Republic of	38,800	21,700	12,700	49,700	27,700	12,700
Malaysia	206	124	32,400	3,340	1,940	25,700
Mexico	6,600	5,350	16,900	6,540	5,240	34,700
Netherlands	23,000	13,200	85,900	38,600	24,200	99,200
New Zealand	361	212	1,930	428	289	2,010
Philippines	54	38	1,360	121	89	1,980
Singapore	847	1,170	578	1,610	2,880	1,050
Spain	3,000	1,700	5,890	1,840	1,080	661
Taiwan	25,100	13,900	2,900	31,200	17,800	3,250
Thailand	2,850	1,620	6,340	3,610	2,210	8,600
United Kingdom	49	71	4	--	--	2
Venezuela	82	198	501	253	2,190	240
Vietnam	3,280	2,040	4,230	2,990	1,940	5,060
Other	2,990	2,620	10,700	5,630	4,270	14,900
Total	171,000	109,000	417,000	264,000	170,000	423,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States (HTS) code 2810.00.0000.

[3] Free alongside ship valuation.

[4] HTS codes 2840.19.0000, 2840.20.0000, and 2840.30.0000.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF BORIC ACID, BY COUNTRY[1]

Country	2009 Quantity (metric tons)	2009 Value[2] (thousands)	2010 Quantity (metric tons)	2010 Value[2] (thousands)
Argentina	841	$637	1,080	$790
Bolivia	2,440	1,550	4,160	2,330
Chile	6,550	4,390	7,340	4,380
China	125	228	100	162
France	750	1,190	505	657
Germany	21	20	103	100
India	192	257	627	607
Italy	1,110	1,250	1,570	1,600
Japan	82	77	173	111
Peru	1,140	896	2,920	1,850
Russia	4,380	2,920	923	483
Turkey	18,300	12,600	30,000	17,000
United Kingdom	54	54	1	2
Other	46	43	27	39
Total	36,100	26,100	49,500	30,100

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] U.S. customs declared values.

Source: U.S. Census Bureau.

TABLE 6
BORON MINERALS: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2006	2007	2008	2009	2010[e]
Argentina	534	670	786	500 [r]	600
Bolivia, ulexite	39 [r]	64	56	86 [r]	97 [3]
Chile, ulexite	460	528	583	608	504 [3]
China[e, 4]	145	145	140	145	150
Iran, borax[e, 5]	2	2 [3]	1 [r, 3]	1 [r]	2
Kazakhstan[e]	30	30	30	30	30
Peru	191	234	350	187	293 [3]
Russia[e, 6]	400	400	400	400	400
Turkey[7]	1,819 [r]	2,128	2,139 [r]	1,800 [r, e]	2,000
United States[8]	W	W	W	W	W
Total	3,620 [r]	4,200	4,480 [r]	3,760 [r]	4,080

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data, not included in total.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 24, 2011.

[3] Reported figure.

[4] Boron oxide (B_2O_3) equivalent.

[5] Data are for years beginning March 21 of that stated.

[6] Blended Russian datolite ore that reportedly grades 8.6% B_2O_3.

[7] Concentrates from ore.

[8] Minerals and compounds sold or used by producers, including both actual mine production and marketable products.

BROMINE

By Joyce A. Ober

Domestic survey data and tables were prepared by Michelle B. Blackwell, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

The United States was the world's leading producer of bromine. The U.S. portion of world production has averaged about 44% during the past 30 years. World production of bromine for 2010, excluding the United States, was estimated to be 450,000 metric tons (t), compared with 378,000 t in 2009 (tables 1, 6). China, Israel, Jordan, the United States, and seven other countries produce bromine. In 2010, bromine sold or used in the United States increased significantly compared with that of 2009, but data were withheld to avoid disclosing company proprietary data.

Bromine is one of two elements that are liquid at room temperature and is found principally as a dissolved species in seawater, evaporitic (salt) lakes, and underground brines associated with petroleum deposits. Primary uses of bromine compounds were in flame retardants (FRs), drilling fluids, water treatment, and brominated pesticides (mostly methyl bromide).

Production

Domestic production data for bromine were developed by the U.S. Geological Survey (USGS) from a voluntary canvass of the two U.S. producers (table 2). Albemarle Corp. and Chemtura Corp., both of which responded to the survey, represent 100% of total production. Production data collected by the USGS were withheld to avoid disclosing proprietary information (table 1). In January, Albemarle and Chemtura announced a strategic sourcing agreement. Chemtura agreed to purchase specific flame-retardant chemicals from Albemarle, and Albemarle assigned its brine interests at a brine unit in Union County, AR, to Chemtura, which is the operator of the unit (Chemtura Corp., 2010).

Bromine was recovered from brine wells in Arkansas, where brine is found in the Smackover Formation at a depth of about 2,400 meters with concentrations of 5,000 to 6,000 parts per million (ppm) bromine; by comparison, seawater contains 60 to 70 ppm bromine (Hill, 2010; Albemarle Corp., 2011, p. 55).

After bromine processing, the spent brine is returned underground into the production formation by class V injection wells that are regulated by the U.S. Environmental Protection Agency (EPA). The chemical composition of the spent brine is generally similar to that of the original, except that the concentration of the target elements (such as bromine and magnesium) is reduced, and the concentration of other elements (such as calcium) may have increased through substitution (U.S. Environmental Protection Agency, 1999, p. 1–2, 5).

Recycling

Some bromide solutions were recycled to obtain elemental bromine and to prevent the solutions from being disposed of as hazardous waste. Hydrogen bromide is emitted as a byproduct from many organic reactions. This byproduct waste is recycled with virgin bromine brines and is a major source of bromine production. Plastics containing brominated FRs (BFRs) can be incinerated as a solid organic waste, and the bromine can be recovered (Frim and Ukeles, 2007).

Consumption

The USGS did not collect consumption data on bromine compounds. Apparent consumption of bromine in the United States, calculated by the USGS from production plus imports minus exports, increased in 2009 owing to expanded demand resulting from improvements in the global economy. The major consumption categories, in order of magnitude, were FRs, drilling fluids, water treatment chemicals, and pesticides. Other uses included butyl rubber, dyes, mercury emission control, pharmaceuticals, photographic chemicals, and surfactants.

Estimated bromine consumption in BFRs was slightly less than 50%; BFRs are chemicals commonly used in many domestic and industrial appliances, electronic equipment, and other items, such as computers, furniture, insulation boards, mattresses, mobile telephones, televisions, and textiles. About 90% of all electrical components contain BFRs.

Late in 2009, Albemarle and Chemtura reached an agreement with the EPA for a voluntary phaseout of decabromodiphenyl ether (decaBDE) flame retardant. DecaBDE is used in consumer electronics, furniture, plastic shipping pallets, and textiles. The two companies signed a memorandum of understanding with the EPA to end production, importation, and sales of decaBDE for most uses by December 2012 and for all uses by the yearend 2013. Although not a producer of decaBDE in the United States, ICL Industrial Products (Tel Aviv, Israel) was a major importer of decaBDE into the United States and also agreed to the phaseout (U.S. Environmental Protection Agency, 2009). Albemarle developed a line of bromine-containing non-decaBDE flame retardants. Bromine was an important component in order to meet fire-safety standards for specific applications (Deligio, 2010).

Calcium bromide, sodium bromide, and zinc bromide, collectively referred to as clear brine fluids (CBFs), were used in the oil- and gas-well-drilling industry for high-density, solids-free completion, packer, and workover fluids to reduce the likelihood of damage to the well bore and productive zone. These high-density fluids also help to prevent migration of fluids between underground formations through the well bore.

Another major use of bromine is as a water purifier and disinfectant, which is an alternative to using chlorine. Brominated compounds are used for water treatment in hot tubs and swimming pools and to control algae and bacterial growth in industrial processes.

Bromine compounds are effective pesticides, used both as soil fumigants in agriculture, particularly fruit growing, and as a fumigant to prevent pests from attacking stored grain and other produce. World trade in agricultural goods depends on the use of bromine compounds to ensure compliance with mandatory quarantine rules. Bromine compounds also are used as intermediates to make other agricultural chemicals. Methyl bromide is the leading bromine-containing pesticide in the world, but its use was declining owing to the ban imposed by the 1987 Montreal Protocol, which classified it as a class I ozone-depleting substance. As part of the Montreal Protocol, wealthy countries were to stop using the pesticide by 2005; however, the United States has received annual exemptions for crops and other critical uses (for example, cucumbers, melons, orchard replants, peppers, post-harvest uses, squash, strawberries, and tomatoes). The critical use exemption is for applications where no technically or economically feasible alternatives to methyl bromide exist. In 2010, the EPA authorized use of 2,984 t or 11.7% of the historic 1991 baseline consumption of methyl bromide for approved critical uses (U.S. Environmental Protection Agency, 2010, p. 23170). Use of methyl bromide also was allowed through a quarantine and preshipment exemption for agricultural commodities and lumber. Methyl bromide is a broad spectrum pesticide used in the control of nematodes, pathogens, pest insects, rodents, and weeds. Domestically, methyl bromide has proven to be difficult to replace because of its low cost and usefulness against a large variety of agricultural pests.

The use of bromine and bromine compounds to remove mercury from flue gas emissions at coal-fired electric powerplants was an expanding new use for bromine. Inorganic bromine compounds, such as calcium bromide and sodium bromide, when mixed with coal at powerplants, react with mercury in combustion zones, forming mercury compounds that are captured in scrubbers, removing 90% of mercury liberated during combustion (Chemtura Corp., 2009). Southern Research Institute (Birmingham, AL) developed a system that converts calcium bromide to elemental bromine gas, which then reacts with mercury to form mercuric bromide. The mercuric bromide is captured and retained in the powerplants' wet scrubbers (Southern Research Institute, 2010).

Albemarle and MeadWestvaco Corp. were partners in developing brominated wood-based activated carbons for use in mercury control (Albemarle Corp., 2009). Chemtura also offered bromine and brominated derivative products for use in the control of mercury emissions from coal-fired plants (Chemtura Corp., 2009).

Transportation

Bromine in bulk quantities is transported in the United States in 7,570- and 15,140-liter (L) lead-lined pressure tank railcars or 6,435- to 6,813-L nickel-clad pressure tank trailers. The trailers must be filled at least 92% full to prevent inertia effects of the heavy liquid while on the highway. International shipments by The Dead Sea Bromine Group are in 15.2- to 23.3-t lead-lined tank containers (isotanks) with a volume of 5,300 to 8,000 L. For smaller quantities, lead lined tanks ("goslars") of 3.5 t (four tanks packed on one isoframe) and cylinders of 400 kilograms are used. Dry nitrogen gas is recommended for use in pressure transferring bromine, although dry air may be used. The gas used must be absolutely dry or severe corrosion results. When exposed to a high-humidity atmosphere, the water content of bromine can exceed 300 ppm. If the water content exceeds 70 ppm, the corrosiveness of bromine to many metals increases (Frim and Ukeles, 2007).

Prices

Because the bromine industry has few producers, published price lists of bromine and bromine compounds were not available. Although companies did not publish price data, they announced price changes without identifying the base price. For instance, Albemarle announced price increases of $500 per metric ton of elemental bromine and $250 per ton of hydrobromic acid twice during the year. By yearend, Albemarle prices for bromine and hydrobromic acid were $1,000 and $500 dollars per ton higher, respectively than at the beginning of 2010, but the actual price was not published. Albemarle and Chemtura made similar announcements throughout the year for other bromine compounds, indicating that prices for most bromine compounds rose during the year. A producer in China reported that elemental bromine reached almost $2,800 per ton in China in August, up from about $1,600 per ton at the beginning of 2010 (Watts, 2010). Prices in China do not necessarily correspond to prices in the United States but tended to corroborate other indications of price levels and trends.

Although not exactly the same as prices, average unit values of exported and imported bromine were used to identify price trends for bromine in 2010. The average value of exported elemental bromine, including cost, insurance, and freight, was $1,760 per metric ton, a 13% increase from $1,560 per ton in 2009. The average values of exported ethylene dibromide and methyl bromide increased 47% and 34%, respectively. The average value of imported elemental bromine increased by about 16% to $2,510 per ton. Price trends for imported bromine compounds varied greatly. The compounds with the highest quantities of imports, however, including ammonium bromide, decaBDE, hydrobromic acid, sodium bromide, and tetrabromobisphenol A (all with more than 1,000 t of imports), all declined in average value, decreasing by 16% on average.

Foreign Trade

Bromine exports were about 33% higher than those in 2009, although still 15% lower than those of 2008 (tables 1, 3). The value of exported elemental bromine and bromine compounds increased by 79% compared with that of 2009, reflecting the significant increase in prices for exported material. Bromine imports were about 25% lower than those of 2009, but total imports of bromine and bromine compounds were 28% higher. The import value of elemental bromine and most bromine compounds decreased, but the increased value of ammonium bromide, hydrobromic acid, potassium bromate, and sodium bromate were sufficient for total bromine imports to incease in value (tables 1, 4). Overall, the import value for elemental bromine and bromine compounds increased by 6% in 2010.

World Review

The United States' share of world bromine production has decreased as other countries have strengthened their positions as world producers of elemental bromine. Israel, the United States, Jordan, China, Japan, and Turkmenistan, in descending order, had the leading bromine production capabilities in 2010, although none of these countries operated at capacity (table 5).

European Union.—In Europe, methyl bromine was banned in 2005 except for critical uses as part of the Montreal Protocol. As of March 18, 2010, all uses of methyl bromide were banned in the European Union without exception (Daily Mail, 2010).

China.—In China, bromine operations are in Shandong Province. Many unlicensed bromine facilities operated in the area, but since 2006, the Shandong Provincial government and the Government of China had closed down the unlicensed operations. Only six companies were licensed to produce bromine.

Gulf Resources, Inc. purchased several of the idled operations. Since 2007 through mid-2010, Gulf Resources acquired nine bromine operations, increasing its bromine production capacity to 46,300 metric tons per year (t/yr) from 12,000 t/yr. Gulf Resources planned to acquire 7 to 10 more bromine facilities. Although Gulf Resources represented only about 20% of China's bromine capacity, the company was perhaps the most well-known as a result of high-profile public relations activities in the United States (Nevader, 2010).

Israel.—ICL Industrial Products (Tel Aviv, Israel) was one of the world's leading producers of elemental bromine, with approximately 40% of global capacity. In 2010, ICL produced 185,000 t of elemental bromine. ICL processes brines from the Dead Sea, which contain 10 to 12 grams per liter (g/l) of bromine, much higher than the next richest source in U.S. brine wells that contain 2 to 6 g/l (ICL Industrial Products, undated).

Outlook

Between 40% and 50% of domestic consumption of bromine is for FRs. In 2010, demand for FRs, particularly in the construction and electronics industries, increased as the economy recovered. Although FR usage fluctuates along with overall cycles in the economy, world consumption of FRs is expected to increase, assuming sustained economic growth. Recycling efforts in Europe for BFR plastics in electrical usage, which are easier to recycle than some other FR compounds, may increase the demand for BFR products. Use of BFRs, however, will likely increase at a slower pace than FRs in general because of legislative mandates and customer demand for more environmentally friendly materials.

The Freedonia Group forecast FR global consumption to rise by 4.7% per year through 2011 (Freedonia Group, The, 2007). The increase would be driven by the use of FRs in developing countries as they begin to adopt more stringent flammability standards and begin to use more plastic materials. Countries in Asia and the Pacific region would be the leading consumers of FRs, with consumption rising by 7% per year. More moderate growth in FR use was expected for markets in North America and Western Europe. U.S. consumption was forecast to rise by 2.7% per year through 2013 as a result of bromine use in insulated wire and cable and in construction as well as more stringent fire codes and flammability requirements (Freedonia Group, The, 2009a). Above-average gains in the demand for FRs were expected to take place in Africa, Eastern Europe, the Middle East, and Latin America.

Bromine use in CBFs is highly dependent on fluctuations in the oil and natural gas drilling industry. Oil and gas drilling activity in the United States, measured by the number of wells drilled, was 12% higher in 2010 than in 2009, as a result of the economic recovery, but was still lower than in 2008 (American Petroleum Institute, 2011). Consumption of CBFs in crude oil and natural gas drilling was expected to increase as demand for these commodities increases.

Bromine water treatment chemical use was expected to show modest growth during the next several years. Bromine is used in both commercial and residential hot tubs, swimming pools, and whirlpools. In addition, bromine is used to treat industrial cooling water. Bromine has been found to be safer than its substitutes in sanitary preparations because bromine has a higher biocidal activity level for the same volume of product. The use of bromine compounds was expected to continue increasing in the hot tub, spa, and swimming pool sector as a gentler disinfectant than chlorine. Global demand for water treatment products was projected to increase in developing markets, such as China and India, as a result of continued industrial expansion and increased efforts to expand access to safe water supplies (Freedonia Group, The, 2009b).

Bromine use in photography is declining as digital imaging replaces film in consumer and professional photography. Most feature films for movie theater presentation are shot using printed film; however, the use of digital technology was expected to increase and overtake film in these applications during the next decade.

The market potential for bromide-based technologies to remove mercury emissions at coal-fired powerplants is an area of potential growth for the industry. Using bromide compounds to neutralize mercury emissions appears to be more cost effective compared with other materials like chlorine-, fluorine-, or iodine-base compounds. New regulations proposed by the EPA in early 2011 for reducing mercury emissions at powerplants by an estimated 91% were likely to increase demand for bromine and bromine compounds for that application (U.S. Environmental Protection Agency, 2011).

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TABLE 1

SALIENT BROMINE STATISTICS[1]

(Metric tons and thousand dollars)

	2006	2007	2008	2009	2010
United States:					
Bromine sold or used:[2]					
Quantity	243,000	W	W	W	W
Value	339,000	W	W	W	W
Exports:[3]					
Quantity	12,400	8,560	9,640	6,120	8,150
Value	23,000	15,200	16,200	12,400	22,300
Imports for consumption:[4]					
Quantity	43,100	32,200	41,200	35,000 [r]	45,000
Value	78,100	817,000	97,300	83,300	88,000
Apparent consumption	275,000	W	W	W	W
World, production[e]	671,000 [r]	415,000 [r, 6]	415,000 [r, 6]	378,000 [r, 6]	450,000 [6]

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Data are rounded to no more than three significant digits.

[2]Elemental bromine sold as such to nonproducers, including exports, or used by primary U.S. producers in preparing bromine compounds.

[3]Export values are free alongside ship.

[4]Source: U.S. Census Bureau or PIERS (see table 4).

[5]Import values are cost, insurance, and freight.

[6]Excludes U.S. production.

TABLE 2
ELEMENTAL-BROMINE-PRODUCING PLANTS IN THE UNITED STATES IN 2010

State and company	County	Plant	Production source	Capacity[1] (thousand metric tons)
Arkansas:				
Albemarle Corp.	Columbia	Magnolia South	Well brines	NA
Do.	do.	Magnolia West	do.	NA
Do.	Union	Satellite plants	do.	NA
Total				148 [2]
Chemtura Corp.	do.	El Dorado Central and El Dorado South	do.	71 [3]
Do.	do.	Marysville West	do.	36
Do.	do.	Newell	do.	23
Total				59
Grand total				278

Do., do. Ditto. NA Not available.

[1] Actual production capacity is limited by brine availability.

[2] Cumulative capacity of Magnolia South, Magnolia West, and Satellite plants.

[3] Cumulative capacity of El Dorado Central and El Dorado South plants.

TABLE 3
U.S. EXPORTS OF BROMINE AND BROMINE COMPOUNDS[1, 2]

Compound	HTS[3] number	2009 (metric tons) Gross weight	2009 (metric tons) Br equivalent	2009 Value[4] (thousands)	2010 (metric tons) Gross weight	2010 (metric tons) Br equivalent	2010 Value[4] (thousands)
Elemental bromine	2801.30.2000	3,810	3,810	$5,930	4,530	4,530	$7,970
Other compounds:							
Ethylene dibromide	2903.31.0000	1,760	1,500	4,320	2,270	1,930	8,180
Methyl bromide	2903.39.1520	968	815	2,190	2,000	1,690	6,090
Grand total		6,540	6,120	12,400	8,810	8,150	22,300

[1] These data detail the information included in table 1 under "Exports."

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Harmonized Tariff Schedule of the United States.

[4] Declared cost, insurance, and freight valuation.

Source: U.S. Census Bureau.

TABLE 4

U.S. IMPORTS OF BROMINE AND BROMINE COMPOUNDS[1, 2]

Compound	HTS[3] number	2009 (metric tons) Gross weight	2009 (metric tons) Br equivalent	2009 Value[4] (thousands)	2010 (metric tons) Gross weight	2010 (metric tons) Br equivalent	2010 Value[4] (thousands)	Principal sources in 2010
Elemental bromine	2801.30.2000	1,390	1,390	$3,020	1,040	1,040	$2,620	Israel, 54%; Jordan, 42%.
Inorganic bromine compounds:								
Ammonium bromide	2827.59.2500	25,600	20,900	39,200	38,600	31,500	50,400	Israel, 93%.
Calcium bromide[5]	2827.59.2500	1,760	1,410	1,690 [e]	255	204	403 [e]	China, 100%.
Potassium bromate	2829.90.0500	54	26	203	53	25	244	China, 100%.
Potassium bromide[5, 6]	2827.51.0000	279	187	1,170 [e]	121	81	249 [e]	France, 53%; Israel, 31%; China, 16%.
Sodium bromate	2829.90.2500	223	118	547	575	305	1,770	China, 100%.
Sodium bromide[5, 6]	2827.51.0000	6,490	5,040	11,900 [e]	8,030	6,230	11,700 [e]	Israel, 70%; China, 19%.
Organic bromine compounds:								
Hydrobromic acid	2811.19.3000	970	958	1,520	1,540	1,520	1,750	Israel, 65%; France, 18%.
Ethylene dibromide	2903.31.0000	105	89	178	21	18	117	China, 95%.
Methyl bromide	2903.39.1520	565	476	4,260	367	309	2,350	Israel, 73%; China, 20%.
Dibromoneopentyl glycol[5]	2905.50.3000	606	345	NA	130	74	618 [e]	Israel, 85%, China, 15%.
Tetrabromobisphenol A	2908.19.2500	1,860	1,090 [r]	7,250	1,310	768	4,410	Israel, 93%.
Decabromodiphenyl oxide and octabromodiphenyl oxide	2909.30.0700	3,810	3,050 [r]	12,400	3,610	2,890	11,500	Israel, 90%; China, 10%.
Grand total		43,700	35,000 [r]	83,300	55,700	45,000	88,000	

[e] Estimated. [r] Revised. NA Not available.

[1] These data detail the information included in table 1 under "Imports for consumption."

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Harmonized Tariff Schedule of the United States.

[4] Declared cost, insurance, and freight valuation.

[5] Source: PIERS.

[6] Potassium bromide and sodium bromide import data are reported under a common HTS number, 2827.51.0000.

Source: U.S. Census Bureau.

TABLE 5
WORLD BROMINE ANNUAL PLANT CAPACITIES AND SOURCES AS OF DECEMBER 31, 2010[1]

Country and company or plant	Location	Capacity (metric tons)	Source
Azerbaijan, Neftechala Bromine Plant	Baku	4,000	Underground brines.
China, Laizhou Bromine Works	Shandong	43,000	Do.
India:			
Hindustan Salts Ltd.	Jaipur	NA	Seawater bitterns from salt production.
Mettur Chemicals Ltd.	Mettur Dam	NA	Do.
Tata Chemicals Ltd.	Mithapur	NA	Do.
Total		1,500	
Israel, ICL Industrial Products	Sdom	280,000	Bitterns of potash production from surface brines.
Japan, Toyo Soda Manufacturing Co. Ltd.	Tokuyama	20,000	Seawater.
Jordan, Jordan Bromine Co. Ltd.	Safi	50,000	Bitterns of potash production from surface brines.
Spain, Derivados del Etilo S.A.	Villaricos	900	Seawater.
Turkmenistan:			
Cheleken Chemical Plant	Cheleken Region	4,740	Do.
Nebitdag Iodine Plant	Vyshka	2,370	Underground brines.
Ukraine, Perekop Bromine Plant	Krasnoperekopsk	3,000	Do.

Do. ditto. NA Not available.

[1] Excludes U.S. production capacity, which is detailed in table 2.

TABLE 6
BROMINE: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010
Azerbaijan	2,000	2,000	3,500	3,500	3,500
China	124,000	137,000	135,000	140,000	150,000
Germany[4]	431 [5]	1,612 [5]	840 r	507 r	985
India	1,500	1,500	1,500	1,500	1,500
Israel	179,493 [5]	159,395 [5]	164,042 [5]	127,689 r, [5]	185,000 [5]
Japan	20,000	20,000	20,000	20,000	20,000
Jordan	94,500 [5]	85,105 [5]	85,000	80,000	85,000
Spain	100	100	100	100	100
Turkmenistan	150	150	150	150	150
Ukraine	5,150 r	7,824 r, [5]	4,416 r, [5]	4,121 r, [5]	4,100
United States[6]	243,000 [5]	W	W	W	W
Total	671,000 r	415,000 r, [7]	415,000 r, [7]	378,000 r, [7]	450,000 [7]

r Revised. W Withheld to avoid disclosing company proprietary data; not included in total.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 11, 2011.

[3] In addition to the countries listed, several other nations, including Iran, produced bromine, but output data were not reported; available general information is inadquate to formulate reliable estimates of output levels.

[4] Includes bromides and oxides.

[5] Reported figure.

[6] Sold or used by producers.

[7] Excludes U.S. production.

CADMIUM

By Amy C. Tolcin

Domestic survey data and tables were prepared by Shonta E. Osborne, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, estimated cadmium metal production in the United States was 637 metric tons (t), about the same as the 633 t produced in 2009 (table 1). Apparent consumption of cadmium was 477 t, a 140% increase from that of 2009. Cadmium metal (including alloys, powders, and waste and scrap) was primarily exported to China (40%), Israel (18%), and the Republic of Korea (13%) (table 3). Germany (30%), Mexico (27%), and Australia (15%) supplied the bulk of the corresponding imports (table 4). The annual average New York dealer price of cadmium metal in 2010 increased by 36% from that of 2009 to \$3.90 per kilogram (\$1.77 per pound).

In 2010, global primary production of cadmium increased slightly to 21,100 t (table 5). Most of the world's primary cadmium was produced in Asia and the Pacific—specifically China, Japan, and the Republic of Korea—followed by Central Europe and Eurasia, North America, and Western Europe. Global secondary cadmium production was estimated to account for about 25% of all cadmium metal production. Most secondary cadmium metal was produced from nickel-cadmium (NiCd) battery recycling.

Leading consumers of refined cadmium were, in descending order of quantity, China, Belgium, and Japan. NiCd battery production continued to be the leading end use of cadmium, accounting for the majority of global cadmium consumption. Other significant end uses of cadmium included alloys, anticorrosive coatings, pigments, polyvinylchloride stabilizers, and semiconducting compounds for solar cells. The percentage of cadmium consumed globally for NiCd battery production has been increasing, while the percentages for the other traditional end uses of cadmium—specifically, coatings, pigments, and stabilizers—have gradually decreased because of environmental and health concerns. The NiCd battery market was concentrated in Asia. Cadmium metal is sold in several shapes and forms, which are used for different types of uses. Slabs or sticks are commonly consumed for alloys; balls and spheres for plating; and flakes, powder, or sticks for chemicals and pigments.

Production

Mine production.—Data on domestic mine production of cadmium were not collected by the U.S. Geological Survey (USGS). Primary cadmium was generally recovered from zinc concentrates. The cadmium content of typical zinc ores ranges from 0.2% to 0.3%. Sphalerite (ZnS), the most economically significant zinc mineral, is commonly impure; cadmium will often substitute for zinc in the crystal lattice. In 2010, zinc-concentrate-producing States were Alaska, Idaho, Missouri, and Tennessee.

Metal production.—Domestic metal production data were collected by the USGS from a voluntary survey on production of cadmium metal and compounds. In 2010, cadmium metal was produced at one primary and two secondary smelters.

Primary.—The Clarksville refinery [owned and operated by Nyrstar NV (Balen, Belgium)] is an electrolytic zinc refinery located along the Cumberland River 80 kilometers (km) northwest of Nashville, TN. The complex's main products were Special High Grade Zinc, galvanizing alloy, and byproducts included cadmium metal, intermediate copper cementate, leach product, sulfuric acid, and synthetic gypsum. Zinc concentrates were sourced from the Tennessee Valley zinc mines, which were also owned by Nyrstar, and from imports.

Secondary.—The International Metals Reclamation Co. (INMETCO) produced secondary cadmium metal (ingot and shot) at its metals recovery facility in Ellwood City, PA. The company was established in 1978 to process stainless steel wastes and then expanded in December 1995 to recycle NiCd batteries. The cadmium recovery plant thermally recovered cadmium from both large industrial and portable consumer NiCd batteries in eight cadmium retort furnaces. The bulk of the cadmium metal produced was sold back to battery manufacturers. Chromium and nickel were also reclaimed in the recovery process as a ferrous remelt alloy for stainless steel production. In addition to NiCd batteries, INMETCO also processed alkaline, lithium, magnesium, nickel chloride, nickel iron, nickel metal hydride, and zinc carbon batteries.

Toxco Inc.'s (Anaheim, CA) recycling operations in Lancaster, OH, also produced secondary cadmium metal in the form of ingots. Cadmium was recovered from NiCd batteries in 12 cadmium retort furnaces. Nickel-iron cells were also produced during the recycling process.

Consumption

Coatings and plating.—Cadmium coatings and plating can be applied to certain metals to prevent their corrosion. The amount of cadmium consumed domestically for coatings and plating decreased during the past several decades as cadmium plated parts were phased out of motor vehicles by the automotive industry. However, cadmium coatings were still used by the aerospace industry and military for some critical applications where coating substitution may compromise operational safety; the metal was commonly used to plate fasteners in aircraft landing gear and parachutes owing to a combination of properties not present in other anticorrosive coatings.

Nickel-cadmium batteries.—NiCd batteries have a high number of charge-discharge cycles, high rate of energy discharge, and a wide operating temperature. They power portable consumer electronics (commonly power tools) and provide emergency backup power for industrial applications and aircraft electrical systems.

Domestically, NiCd batteries were thought to have been produced at six facilities operated by four battery manufacturing companies. Globally, leading NiCd battery manufacturers were BYD Co., Ltd. (Pingshan, Shenzhen Province, China), Panasonic Corp. (Japan), and Sanyo Electric Co., Ltd. (Japan). NiCd battery use in consumer electronics was thought to be declining owing partly to the preference for other rechargeable battery chemistries—particularly lithium ion (Li-ion) batteries, which have already replaced NiCd batteries in cellular telephones and laptops owing to their high energy density. However, NiCd batteries have a cost advantage compared with other battery chemistries and are still favored for use in less expensive consumer appliances and electronics.

Industrial-sized NiCd batteries potentially could be used to store energy produced by certain on-grid solar or wind systems. About 2% of the Nation's power was generated by solar cells and wind farms. If this percentage were to increase to more than 10%, mass energy storage may be required for load leveling. Excess energy during periods of low electricity demand could be stored in a battery storage system, from which it would be later dispatched during periods of high electricity demand. NiCd batteries may be a favored battery chemistry for this use owing to their stability in offshore and harsh weather environments.

Pigments.—Cadmium pigments are inorganic and based on cadmium sulfide, which is golden yellow in color. The increased replacement of zinc or mercury for cadmium and selenium for sulfur forms the spectrum of cadmium pigments that range from bright yellow to maroon. Cadmium pigments are predominantly used to color plastics that are processed at higher temperatures, as the pigments are able to withstand the elevated temperatures without degrading.

Solar cells.—Cadmium telluride (CdTe) flexible thin-film solar cells are an alternative to traditional crystalline silicon solar cells and are practical for commercial rooftop applications and large-scale, ground-mounted utility systems. CdTe photovoltaic cells are potentially a safe, environmentally friendly application for cadmium; the cadmium would remain contained and recyclable. CdTe cells contain an average of 7 grams (g) of cadmium per square meter. This equates to 70 g of cadmium per kilowatt of electric power produced, assuming the cells are 10% efficient. Companies involved in developing CdTe thin-film technology within the United States included Ascentool, Inc., AVA Solar, Inc., Canrom Photovoltaics, Inc., China Nuvo Solar Energy, First Solar, Inc., Primestar Solar, Inc., Solar Fields LLC, and Zia Watt Solar (Ullal and von Roedern, 2007).

Prices

Platts Metals Week publishes a weekly and monthly New York Dealer price for cadmium (minimum 99.95% purity) in dollars per pound. The 2010 average New York Dealer price for cadmium was $3.90 per kilogram ($1.77 per pound), 36% more than the average price in 2009. The average monthly New York dealer price in January was $3.64 per kilogram ($1.65 per pound). Average monthly prices reached a yearly high in April at $4.52 per kilogram ($2.05 per pound) and then generally decreased during the remainder of 2010, ending at $3.57 per kilogram ($1.62 per pound) in December.

World Industry Structure

In 2010, most of the world's refined cadmium was produced in Asia and the Pacific, specifically China, Japan, and the Republic of Korea, followed by Central Europe and Eurasia, North America, and Western Europe.

Global secondary cadmium production was thought to have accounted for approximately a quarter of all cadmium metal production. Most secondary metal was produced at NiCd battery recycling facilities in Asia, Europe, and the United States. In Japan, NiCd battery recyclers included Kansai Catalyst Co., Ltd., Mitsui Mining and Smelting Co., Ltd., and Toho Zinc Co., Ltd. In Europe, NiCd battery recycling took place at Accurec GmbH's facility in Germany, Saft AB's plant in Sweden, and Societe Nouvelle D'Affinage des Metaux's two recycling facilities in France.

World Review

Australia.—Most of the cadmium metal produced domestically was exported; a small amount was consumed in the country by specialized electroplating industries. Nyrstar's Hobart zinc smelter, in Tasmania, produced cadmium metal from cadmium-bearing zinc concentrates sourced from the Century and Rosebery zinc-lead mines.

Sun Metals Corporation Pty. Ltd.'s (a subsidiary of Korea Zinc Co., Ltd.) zinc refinery near Townsville, northern Queensland, had the capacity to produce 1,000 metric tons per year (t/yr) of cadmium cake (containing 75% to 80% cadmium). Sun Metals was thought to have exported most of the cadmium cake to Korea Zinc's Onsan zinc-lead refinery in the Republic of Korea, where it was refined into metal (Park, undated, p. 5).

Belgium.—Belgium was a significant consumer of refined cadmium. Most of this consumption took place at Floridienne Chimie S.A.'s plant for the production of cadmium compounds (carbonate, nitrate, and oxide) and powder, which were then exported to downstream consumers. It was estimated that the company consumed 4,800 to 7,200 t/yr of refined cadmium, accounting for almost 40% of global cadmium production.

Brazil.—Votorantim Metais' (Sao Paulo, a unit of Grupo Votorantim) Juiz de Fora zinc smelter in Minas Gerais was the sole producer of refined cadmium in Brazil.

Canada.—Teck Resources Ltd. (Vancouver, British Columbia) produced approximately 1,000 t/yr of refined cadmium at its metallurgical complex at Trail, British Columbia. Refined zinc and lead metal were the main products produced at Trail along with a number of byproducts that included copper compounds, germanium dioxide, gold, indium, silver, and various sulfur products. The cadmium plant at Trail was constructed in 1991 to handle the increased cadmium input from the Red Dog Mine in Alaska and can produce up to 1,400 t/yr of refined cadmium. Cadmium metal products, which were mostly consumed by NiCd battery manufacturers, included balls, billets, and sticks. Teck also produced cadmium chemicals and continuously cast cadmium sheet. Cadmium sheet is commonly used to shield radiation measurement and control devices from slow neutrons. HudBay Minerals Inc.'s (Winnipeg, Manitoba) copper smelting and zinc refining operations in Flin Flon, Manitoba, also produced byproduct cadmium metal.

India.—Hindustan Zinc Ltd. (HZL, Udaipur) produced cadmium metal at its Chanderiya lead-zinc smelter complex, Debari zinc smelter, and Vizag zinc smelter in the form of sticks. During the financial year ending March 31, 2011, HZL's cadmium metal production capacity was 833 t/yr. Cadmium production capacity by plant was as follows—Chanderiya, 460 t/yr; Debari, 235 t/yr; and Vizag, 138 t/yr. HZL produced 493 t of cadmium during its 2010–11 financial period. During its next financial year, HZL planned to begin producing higher grades of refined cadmium. High-purity cadmium is typically used for nuclear shielding applications (Hindustan Zinc Ltd., 2011, p. 52, 100).

Binani Zinc Ltd. also produced cadmium at its zinc plant in Binanipuram. Production capacity was 65 t/yr of refined cadmium.

Korea, Republic of.—Korea Zinc (Seoul) was one of the leading suppliers of cadmium metal to China. Production capacity of refined cadmium at the company's leading smelter, the Onsan zinc-lead refinery in Kyoung Nam Province, was approximately 3,000 t/yr. Cadmium was also produced at Young Poong Corp.'s (Seoul) Sukpo zinc refinery in the form of sticks. Cadmium production capacity at Sukpo was 805 t/yr.

Mexico.—Refined cadmium in Mexico was produced mainly at Industrias Peñoles S.A. de C.V.'s Met-Mex metallurgical complex in Torreon (in the form of balls and sticks) and at Grupo Mexico S.A. de C.V.'s electrolytic zinc refinery in San Luis Potosi (in the form of ingots, mini-jumbos, spheres, and sticks). Cadmium-bearing zinc concentrates treated at San Luis Potosi were sourced from Grupo Mexico's mines, principally the Charcas zinc mine. About 60% of the zinc concentrates processed at Met-Mex originated from Industrias Peñoles' mines.

Peru.—Cadmium metal was produced at Votorantim's Cajamarquilla zinc refinery (430 t/yr of production capacity). Doe Run Peru's (Lima) La Oroya metallurgical operations also had the capacity to produce cadmium. However, operations at the smelter ceased in 2009 owing to environmental and financial problems.

Russia.—Cadmium metal in Russia was produced at Chelyabinsk Zinc Plant OJSC's (Chelyabinsk) zinc refinery and Ural Mining and Metallurgy Company's (Sverdlovsk) Electrozinc lead-zinc refinery.

Outlook

Concern over cadmium's toxicity has spurred various legislative efforts, especially in the European Union, to restrict the use of cadmium in most of its applications. However, cadmium-containing residues will continue to be produced as a byproduct from the zinc smelting process, regardless of cadmium demand. If the applications and markets for cadmium continue to decline, excess byproduct cadmium may need to be permanently stockpiled and managed, similar to the situation that the U.S. Government now faces with mercury.

However, demand for cadmium may increase owing to several new market opportunities for NiCd batteries, particularly in industrial applications. NiCd batteries power some battery electric vehicles in circulation and are also used as a source of power in a limited number of hybrid electric vehicles. NiCd batteries have been used to support various renewable energy installations owing to their long service life, low maintenance, and stability in harsh weather environments. NiCd batteries were also used as a buffer in transportable, renewable hybrid-power systems developed to generate electricity in remote locations and underdeveloped regions.

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TABLE 1
SALIENT CADMIUM STATISTICS[1, 2]

		2006	2007	2008	2009	2010
United States:						
Production of metal[3, 4]	metric tons	723	735	777	633	637
Shipments of metal by producers[4, 5]	do.	833	692	774	737	563
Exports of metal, alloys, scrap	do.	483	424	421	661	306
Imports for consumption, metal, alloys, and scrap	do.	180	316	197	122	221
Apparent consumption of metal	do.	530	594	528	199	477
Price, average, New York dealer[6]	dollars per pound	1.35	3.45	2.69	1.30	1.77
Do.[6]	dollars per kilogram	2.98	7.61	5.92	2.87	3.90
World, refinery production	metric tons	19,900	19,400	22,800 [r]	20,800 [r]	21,100 [e]

[e]Estimated. [r]Revised. Do., do. Ditto.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Cadmium content.

[3] Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.

[4] Partially estimated.

[5] Includes metal consumed at producer plants to make oxide and other cadmium compounds.

[6] Price for 1- to 5-short ton lots of metal having a minimum purity of 99.95% (Platts Metals Week).

TABLE 2
SUPPLY AND APPARENT CONSUMPTION OF CADMIUM METAL[1, 2]

(Metric tons)

	2006	2007	2008	2009	2010
Producer stocks, January 1[3]	184	74	107	132	27
Production[3]	723	735	777	633	637
Imports for consumption, metal, alloys, and scrap	180	316	197	122	221
Total supply	1,090	1,130	1,100	887	885
Exports of metal, alloys, scrap	483	424	421	661	306
Producer stocks, December 31[3]	74	107	132	27	102
Consumption, apparent[4]	530	594	528	199	477

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes supply and apparent consumption of cadmium sulfide, cadmium telluride, and related cadmium chemicals.

[3] Partially estimated. Beginning stocks may not equal ending stocks of the prior year owing to inventory adjustments.

[4] Total supply minus exports and yearend stocks.

TABLE 3
U.S. EXPORTS OF CADMIUM PRODUCTS, BY COUNTRY AND TYPE[1]

	2009		2010	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Cadmium (Cd) metal:[2]				
Belgium	900	$18,100	--	--
Canada	22,300	129,000	28,900	$145,000
China	335,000	823,000	122,000	350,000
Germany	29,700	443,000	23,600	292,000
Hong Kong	116,000	64,800	19,200	10,800
Israel	17,000	69,300	53,600	342,000
Korea, Republic of	76,900	274,000	38,500	99,400
Netherlands	17,000	161,000	--	--
Pakistan	40,400	17,700	--	--
Sweden	--	--	15,000	56,200
United Kingdom	3,380	22,600	--	--
Other	2,870 [r]	102,000 [r]	5,410	221,000
Total	661,000	2,120,000	306,000	1,520,000
Of which:				
Unwrought and powder	276,000	1,270,000	75,300	571,000
Waste and scrap	137,000	319,000	--	--
Other	249,000	537,000	231,000	945,000
Cadmium sulfide, gross weight:				
Germany	--	--	9,990	5,200
Mexico	--	--	30,800	16,000
Switzerland	5,640	2,940	6,140	3,190
United Kingdom	10,600	5,510	--	--
Total	16,200	8,440	46,900	24,400
Total, calculated Cd content	12,600	XX	36,500	XX
Cadmium pigments:				
Argentina	--	--	60,100	123,000
Brazil	11,300	52,300	9,030	99,200
Canada	116,000	1,820,000	316,000	2,350,000
China	13,600	44,500	36,300	158,000
Colombia	5,840	44,100	2,110	13,400
Dominican Republic	6,180	41,600	3,520	20,100
France	--	--	5,350	42,500
Germany	3,260	44,100	3,460	17,800
Guatemala	96,300	156,000	96,300	172,000
Hong Kong	24,600	42,200	2,330	10,700
Israel	3,760	31,200	13,000	117,000
Italy	--	--	2,560	16,200
Jamaica	58,800	99,600	12,800	26,700
Mexico	904,000	3,580,000	1,430,000	4,660,000
New Zealand	--	--	9,320	9,270
Switzerland	10,800	1,090,000	11,300	669,000
Taiwan	--	--	3,430	15,000
Trinidad and Tobago	34,500	85,200	14,300	25,500
United Kingdom	211	4,480	6,120	21,300
Other	50,600 [r]	229,000 [r]	10,300	129,000
Total	1,340,000	7,360,000	2,050,000	8,700,000

[r] Revised. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes exports of other cadmium (Schedule B 8107.9000) and waste and scrap (Schedule B 8107.3000).

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS OF CADMIUM PRODUCTS, BY COUNTRY AND TYPE[1]

	2009		2010	
	Quantity (kilograms)	Value	Quantity (kilograms)	Value
Cadmium (Cd) metal:[2]				
Australia	38,000	$121,000	34,000	$135,000
Belgium	14,800	301,000	16,600	365,000
Canada	21,700	576,000	7,530	612,000
China	4,020	109,000	15,500	136,000
Germany	4,040	38,200	66,300	315,000
India	--	--	125	11,600
Japan	3	3,210	28	19,500
Mexico	11,500	25,500	60,000	236,000
Norway	--	--	20,000	1,040,000
Peru	24,000	63,000	--	--
Russia	--	--	30	9,300
United Kingdom	3,960	247,000	1,270	37,400
Total	122,000	1,480,000	221,000	2,910,000
Of which:				
Unwrought and powder	117,000	1,110,000	216,000	2,400,000
Waste and scrap	--	--	59	6,120
Other	4,940	371,000	4,910	509,000
Cadmium oxide:				
Belgium	115,000	760,000	201,000	1,750,000
India	--	--	540	13,000
Japan	240	19,800	--	--
Netherlands	5,230	50,000	--	--
United Kingdom	25	2,200	--	--
Total	120,000	833,000	202,000	1,770,000
Total, calculated Cd content	105,000	XX	177,000	XX
Cadmium sulfide, gross weight:				
Canada	55,900	446,000	140,000	611,000
Germany	--	--	122	32,400
India	--	--	830	17,100
Russia	74,000	1,960,000	115,000	2,730,000
United Kingdom	4,720	21,200	2	4,200
Total	135,000	2,420,000	255,000	3,400,000
Total, calculated Cd content	105,000	XX	199,000	XX
Cadmium pigments:				
Belgium	750	11,100	850	12,600
Brazil	1,990	51,300	9,790	250,000
Canada	2,770	36,500	2,540	53,700
China	2,000	8,800	--	--
Colombia	--	--	9,000	24,800
Germany	62,900	414,000	110,000	759,000
India	3	7,560	--	--
Japan	487	42,200	58	11,300
Netherlands	--	--	892	5,840
Sweden	--	--	1	3,460
United Kingdom	58,900	1,050,000	99,400	1,730,000
Total	130,000	1,630,000	232,000	2,850,000

XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes imports of other cadmium [Harmonized Tariff Schedule of the United States (HTS) 8107.90.00] and waste and scrap (HTS 8107.30.00).

Source: U.S. Census Bureau.

TABLE 5
CADMIUM: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Argentina	6	35	38	36 [r]	35
Australia	329	351	350	370	350
Brazil	141	200 [e]	200 [e]	200	200
Bulgaria	363	459	460 [e]	420 [r]	440
Canada[4]	2,090	1,388	1,409	1,299	1,300 [e]
China[e]	3,790	4,210	6,960 [r]	7,000 [r]	7,200
Germany[e]	640	400	420 [r]	278 [r]	400
India	457	583	599	610	620
Italy[e]	10	10	10	10	10
Japan	2,287	1,933	2,116	1,824	2,053 [5]
Kazakhstan	2,000	2,100	2,100 [e]	1,800	1,800
Korea, North[e]	200	200	200	200	200
Korea, Republic of	3,320	2,846	3,090	2,500 [r]	2,500
Mexico[6]	1,401	1,617	1,550	1,210	1,483 [5]
Netherlands	524	495	530	490	580
Norway	125	269	178	249	300 [5]
Peru	416	347	371	375	400 [p]
Poland	373	421	603	534 [r]	530
Russia	690	810	800	700	NA
Ukraine[e]	25	25	25	25	25
United States[4]	723	735	777	633	637 [5]
Total	19,900	19,400	22,800 [r]	20,800 [r]	21,100

[e] Estimated. [p] Preliminary. [r] Revised. NA Not available.

[1] This table gives unwrought production from ores, concentrates, flue dusts, and other materials of both domestic and imported origin. Sources generally do not indicate if secondary metal (recovered from scrap) is included or not, where known, this has been indicated by a footnote. Data derived in part from World Metal Statistics (published by World Bureau of Statistics, Ware, United Kingdom) and from Metal Statistics (published jointly by Metallgesellschaft AG of Frankfurt am Main, Germany, and World Bureau of Metal Statistics). Cadmium is found in ores, concentrates, and (or) flue dusts in several other countries, but these materials are exported for treatment elsewhere to recover cadmium metal; therefore, such output is not reported in this table to avoid double counting. This table includes data available through May 4, 2011.

[2] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[3] Romania, Thailand, and Uzbekistan may produce primary cadmium metal or oxide, but information is inadequate to make reliable estimates of output.

[4] Includes secondary.

[5] Reported figure.

[6] Excludes significant production of both cadmium oxide and cadmium contained in exported concentrates.

CEMENT

By Hendrik G. van Oss

Domestic survey tables were prepared by Richard H. Kraft, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Production of portland and masonry cement in the United States in 2010 totaled 66.4 million metric tons (Mt) (table 1). This was nearly 4% higher than production in 2009, but output in 2009 was the lowest since 1983. Measured by sales to domestic final customers, domestic consumption of cement in 2010 declined slightly to 70.5 Mt (table 9) and thereby replaced 2009 as the lowest sales volume year since 1983. However, the decline in 2010 was mostly because of very low sales volumes in the first 2 months of the year; sales for the remainder of the year showed a 3% increase overall. In perspective, consumption in 2010 was 57.5 Mt, or 45%, lower than the record level in 2005. Whereas the large (nearly 27%) decline in sales volumes in 2009 was accompanied by comparatively modest (4%) price decreases, prices fell substantially in 2010 and the overall value of sales fell by nearly 8% to about $6.5 billion (tables 1, 11–13). Based on typical portland cement mixing ratios in concrete, the delivered value of concrete (excluding mortar) in the United States was estimated to be at least $37 billion in 2010. World cement production increased by 9% to 3.31 billion metric tons (Gt).

Percentage or other changes expressed in this report compare activity in 2010 with that of 2009 unless specified otherwise. Except where otherwise indicated, data and trends in this report exclude those in Puerto Rico. Cements covered in this report are mainly limited to those hydraulic varieties broadly classified as portland cement (including blended cement and other varieties listed in table 15) and (or) masonry cement (including portland-lime and plastic cements); these are the binding agents in concrete and most mortars. A few other types of hydraulic cements and (or) clinker (notably aluminous cement) are included in some of the trade data (tables 16–18 and 21) and within the world production data (table 22). Except where incorporated as components within finished portland (blended) or masonry cements or as raw feed for clinker, this report's tables exclude supplementary cementitious materials (SCM), such as fly ash, other pozzolans, and ground granulated blast furnace slag (GGBFS). Sales data for blended (also called composite) cements listed separately from portland cement are available in the monthly Mineral Industry Surveys reports of the U.S. Geological Survey (USGS).

The bulk of this report is based on data compiled from USGS annual questionnaires sent to cement and clinker manufacturing plants and associated distribution facilities and import terminals, and some terminals that are independent of U.S. cement manufacturers. For 2010, questionnaires were received from 154 of 159 facilities canvassed, a response rate of 97%, which included all of the production sites. Not all forms were returned fully completed, but the data received included 100% of the 2010 cement and clinker production and 99% of the total cement sales tonnages tabulated in this report. For 2009, questionnaires were received from 152 of 156 facilities canvassed, a response rate of 97%, which included all of the production sites. If missing data could not be obtained by followup telephone inquiries, they were estimated based on monthly data or past annual reporting. For both years, the data exclude several importers that have yet to participate in the surveys. To the degree that they are independent of the participating companies, sales by the missing importers for 2009 and 2010 are estimated to be no more than an additional 1% of the total portland cement sales tonnages shown in this report. General background information on cement and its manufacture and on the USGS cement canvasses is given in van Oss (2005).

Government Programs and Environmental Issues

Various Government programs provide funding and direction for public sector construction and are thus of importance to cement consumption levels when budgets are actually established. By comparison to some other construction materials, however, concrete can be less sensitive to rapid swings in construction spending levels, owing, in part, to lead times preparatory to concrete construction and the common need to coordinate between State and Federal agencies. Because of very low cement sales volumes, it was likely that very little of the 2009 Recovery and Reinvestment Act (ARRA) ("stimulus") funding was spent in 2009 on concrete construction projects, it had been widely anticipated that concrete projects would benefit from ARRA spending in 2010. By yearend 2010, continued lackluster cement consumption levels indicated that little stimulus spending had gone to concrete projects in that year either.

Environmental issues pertaining to the cement industry are mostly associated with the manufacture of the intermediate product called clinker. In making clinker, the consumption of large amounts of raw materials and fuels leads to large emissions of carbon dioxide (CO_2), and can yield significant emissions (if not scrubbed out) of nitrogen oxides (NOx), sulfur oxides (SOx), mercury and some other metals, volatile organic carbon compounds, and particulates. Increasingly, these emissions are regulated or are being considered for regulation or reregulation.

The largest volume emissions are of CO_2; the cement industry is one of the leading industrial emitters of this greenhouse gas (GHG). Overall, generation of CO_2 by the U.S. cement industry in 2010 was calculated to be in the range of 0.87 to 0.92 metric ton (t) of CO_2 per ton of clinker produced; the high end incorporates fuel combustion emissions calculated using "standard" heat values for the fuels consumed (table 7), and the low end incorporates heat values actually reported by the individual plants. Both ratios are unchanged from those of 2009, and include a standard emissions factor from calcination of limestone of 0.51 t of CO_2 per ton of clinker as detailed by the Intergovernmental Panel on Climate Change (Hanle and others, 2006), but exclude any correction for cement kiln dust (CKD) not recycled to the kiln (for which data are lacking). The standard calcination component of CO_2 emissions can be reduced in the calculation in proportion to the calcium oxide contributed by noncarbonate alternative raw materials such as ferrous slags and coal combustion ashes. This incorporation would allow a reduction of calcination-related emissions of about 2.5% (0.8 Mt) in 2010 and 2.4% (0.7 Mt of CO_2) in 2009; relative reductions can be significantly larger for the subset of individual plants that actually burn these alternative raw materials. Certain fuels, including alternative or waste fuels, can either directly reduce plant-level CO_2 emissions or may be allowed to be deducted from reported combustion emissions because the fuels are considered to be carbon-neutral (certain biofuels) or because credits may be allowed for their use (certain waste fuels). Fuel deductions have not been made in the averages noted above. Plant-level emissions can be reduced through upgrading to more fuel-efficient kiln line technology. Unit emissions on a finished product basis can also be reduced by use of SCM in finished cement and in concrete to reduce the clinker content of these products and (or) by allowing the addition of "inert" fillers to boost cement output without simultaneously boosting clinker output.

The U.S. Environmental Protection Agency (EPA) has long used methods similar to those used above to calculate and report overall U.S. levels of GHG emissions by various industries; for cement, these methods made use of national-level clinker production data published by the USGS. However, to eventually refine the determination of U.S. emissions of GHG, the EPA released a final rule for mandatory site/plant-specific reporting of GHG emissions, with reporting to begin in 2010 (U.S. Environmental Protection Agency, 2009b). For the cement industry's CO_2 emissions, relevant calculation procedures were covered under Part 98, subpart C (p. 56397–56411) for fuel combustion, and in subpart H (p. 56420–56422) for calcination and related process emissions. The published results of the 2010 mandatory reporting (U.S. Environmental Protection Agency, 2012), combined with USGS data for clinker production, show an average emission of 0.90 t CO_2 per ton of clinker, excluding the EPA addition of minor CO_2-equivalent emissions of methane and nitrous oxide (N_2O); this is in close agreement with the USGS estimate noted above.

In September 2010, the EPA issued the final rule pertaining to the national emissions standards for hazardous air pollutants (NESHAP), in which new, very low, limits on individual plant emissions of mercury, total hydrocarbons, particulate matter (as a surrogate for nonvolatile metal pollutants), and hydrochloric acid were established for cement plants that do not burn hazardous wastes (U.S. Environmental Protection Agency, 2010c). The final rule revised the emissions limits in the 2009 proposed NESHAP (U.S. Environmental Protection Agency, 2009a); for mercury, the final rule's standards were 55 pounds of mercury per million short tons of clinker for existing plants (revised from 43 pounds); and 21 pounds of mercury (revised from 14 pounds) for new plants. It remained unclear how many plants could meet the standards using their current mix of raw materials and fuels without installing a mercury scrubber. Likewise, it was unclear how many, if any, plants could meet the NESHAP standards for all four pollutants. The rule provided for a 3-year compliance timeframe.

In June 2010, in response to a 2007 District of Columbia Circuit Court of Appeals decision vacating several of the definitions within the commercial and industrial solid waste incineration units (CISWI) sections of the Resource Conservation and Recovery Act (RCRA), the EPA issued proposed new definitions as to what nonhazardous secondary materials would be considered to be solid wastes (U.S. Environmental Protection Agency, 2010a). This ruling potentially would affect the regulatory status of a large number of cement plants because many of them routinely burn a variety of alternative raw materials and fuels instead of, or as partial substitution for, traditional geological raw materials and fuels.

In June, the EPA proposed options for modifying how coal combustion residuals (CCRs, also known as coal combustion products or byproducts), particularly fly ash, were to be regulated under RCRA. Under one option, CCRs would be classified as "special waste" and subject to regulation under subtitle C when destined to be landfilled but not when beneficially reused. Under the second option, disposal of the CCRs would essentially remain as currently regulated under subtitle D (U.S. Environmental Protection Agency, 2010b). Concern in the construction sector was that if fly ash were to be reclassified as a hazardous waste, even under restricted circumstances, the material would be stigmatized and demand for it would decrease or cease altogether (Goss, 2010).

Production

Output of portland cement increased by 4.2% to 64.5 Mt in 2010 (table 3), after a nearly 26% decline in 2009. Following a weak first quarter, production responded to modest increased sales demand thereafter, but, except for 2009, output for the year remained the lowest since 1991. Although most of the cement import terminals are controlled by the domestic cement producers, with import volumes mainly in response to production shortfalls, closure or idling of some independent import facilities may have stimulated some of the additional domestic production. Production increases and declines among districts were mixed, but most declines were small. A few districts (especially Missouri) showed substantial increases. Yearend stockpiles increased by about 2%.

Overall annual production capacity in 2010 was about 122 Mt, a slight decline resulting from the closure in 2009 of four plants; one each in California, Pennsylvania, Michigan, and Missouri. The plant count in 2010 reflects these closures, but that in California is somewhat artificial because the 2009 count retained an essentially idle facility that produced a small quantity of masonry cement (hence retained active grinding capacity) in that year but which was considered closed in 2010. In reality, both years show somewhat inflated plant counts and grinding capacities, because while certain plants remained officially idle for all of both years, no formal closure announcements for them had been made as of yearend 2010. Most of these idle facilities remained active as distribution terminals.

Continued weakness in the housing, especially multifamily units, construction sector led to a 3.4% decline in masonry cement production in 2010 to just 1.9 Mt (table 4), the lowest level since at least 1954. The percentage decline in 2010, however, was much lower than the 35% decrease in production in 2009 relative to that in 2008.

With multiple subsidiaries of common parents combined under the larger subsidiary's name and with joint ventures apportioned, the 10 leading companies at yearend 2010, in descending order of portland cement production, were CEMEX, Inc., Holcim (US) Inc., Lafarge North America Inc., Lehigh Cement Co., Buzzi Unicem USA Inc. (including Alamo Cement Co.), Ash Grove Cement Co., Essroc Cement Corp., Texas Industries, Inc. (TXI), Eagle Materials Inc., and St. Marys Cement Group. The U.S. industry continued to be heavily consolidated, with the 5 leading cement companies, combined, contributing nearly 60% of total U.S. portland cement production, and the 10 leading companies accounting for 82% of total production. Of the above named companies, all except Ash Grove and TXI were foreign owned as of yearend, and for the U.S. industry overall, about 81% of total cement output was by foreign-owned companies.

Clinker output in 2010 increased by 6.6% to 59.8 Mt (tables 1, 5) but, except for 2009, was still the lowest production since 1983. Clinker production actually increased significantly in nearly all months after March, but January through March showed a 13.3% decline overall. Apparent annual production capacity declined by about 4% to 109 Mt, reflecting kiln and (or) plant closures the previous year, but utilization of capacity increased modestly to about 55% from 49% in 2009. Utilization in 2010 was still well below the presumed "full practicable" capacity utilization rates of 85% or more experienced during years of high cement sales volumes. It should be noted that the utilization statistic is dependent on the reported downtime for routine maintenance. As in 2009, many plants reported much longer than normal downtimes for this purpose in 2010; where this was obvious, corrections were made in both years (after consultation with the plants) to remove the extra downtime (a result of slow sales) from the statistic. Yearend clinker stockpiles showed an overall decline of 7.2%. This apparent drawdown would appear to indicate production shortfalls relative to subsequent cement production, but the statistic is difficult to fully evaluate because of regional variation in the clinker stock changes and because many kilns continued idle for much or all of the year. In terms of kiln technology, the count for wet plants in 2010 fell by four because of the closure in 2009 of wet plants; one each in Michigan, Missouri, and Pennsylvania; and the replacement of the wet kilns with a precalciner (dry) kiln in 2010 (hence shift to "Both" status for the year) at a plant in Arkansas. The dry plant count increased by two because of the permanent shutdown in 2009 of the wet kilns at former combination ("Both") plants in Pennsylvania and West Virginia.

Nonfuel raw materials consumed to make clinker and cement are listed in table 6. Ratios among the raw materials and between them and the total cement and clinker produced in 2010 appear to be broadly similar to those in 2009; apparent changes or substitutions may reflect consumption at a relatively small number of plants. One apparently significant change is a 22% increase in the consumption of granulated blast furnace slag for cement; this is in accord with increased sales of blended cements that contain GGBFS, although the relative sales increase is even larger (table 15).

For fly ash and bottom ash, the table 6 data in the past have been similar to those published by the American Coal Ash Association (ACAA) for sales during the year for use in making clinker and cement (combined). For 2010, however, the ACAA tonnage for fly ash (1.856 Mt) was 26% lower than that in table 6, and the ACAA tonnage for bottom ash (0.861 Mt) was 18% higher (American Coal Ash Association, 2011). It is unclear if the differences represented an issue of actual sales (as reported by the ACAA) versus consumption, including from stockpiles (table 6), or problems with mischaracterization of the material in one or both surveys. The "Gypsum and anhydrite" data for 2010 in table 6 included 0.801 Mt of synthetic gypsum, but this may underrepresent actual use of the synthetic material because a split, if any, between natural and synthetic gypsum is not required by the USGS canvass. In recent years, the USGS data for synthetic gypsum have exceeded those reported by the ACAA, likely because the ACAA does not survey the cement plants' own production of the synthetic material. In 2010, however, the ACAA reported 1.03 Mt of synthetic gypsum sales to the cement industry.

Data on fuel consumption by the cement industry are listed in table 7. Data shifts can reflect activities at just a few plants. In terms of overall mass ratios among fuels in total and relative to clinker production, significant declines in 2010 were especially evident for wet plants, reflecting the lower plant count. For dry plants, a decline in fuel oil consumption was likely because of escalating fuel oil prices and appears to have been more than offset by an increase in consumption of liquid waste fuels.

Although not shown in table 7, overall heat consumption (gross heat basis) in 2010 was about 4.1 billion joules (GJ) per metric ton of clinker, down slightly (2.6%) from the revised average for 2009. The reduction appears to reflect a combination of the closure of wet plants in 2009 and of wet kilns at two former combination plants (which were thus dry plants in 2010), and the addition of a dry kiln at a former wet plant. Heat consumption at the remaining operational wet plants averaged 6.7 GJ per ton of clinker, very slightly (probably of no statistical significance) higher than the revised average for 2009, and dry kilns averaged 4.0 GJ per ton of clinker, very slightly lower. It remained unclear whether or not the industry was experiencing any heat (efficiency) penalties for the common practice in 2009 and 2010 of operating kilns on an intermittent basis and with longer overall downtimes than customary in busy years. For the industry overall, coal continued to supply the largest share of total heat consumed (62%, up by about 3%), followed by petroleum coke (about 19%, down by nearly 10%), and waste fuels (14%, up by 8%).

Average unit electricity consumption was substantially unchanged in 2010 for the industry overall and for dry plants, but increased at the remaining wet plants (table 8). As with heat consumption, many plants operated on an intermittent basis in 2009 and 2010, and this has made it difficult to evaluate changes related to closures of older facilities and to technology upgrades.

The only significant ownership change in 2010 within the U.S. cement industry was the purchase in May of Continental Cement Co. by Summit Materials, LLC (2010). Continental was an independent company that operated a 1.0-million-metric-ton-per-year precalciner kiln plant at Hannibal, MO. Toward yearend, Drake Cement LLC completed construction of its new 1,800-metric-ton-per-day (t/d) integrated plant at Drake, AZ. Production of clinker and cement was expected to commence in early 2011. Drake Cement was a subsidiary of Peruvian company Cementos Lima SA.

The pace of plant closures and long-term idlings slowed in 2010 by comparison to 2008 and 2009. In March 2010, CEMEX closed the Wampum, PA, plant, which had been the oldest continuously operating cement plant in the country. In December, Buzzi Unicem announced that the "indefinite idle" status of its Oglesby, IL, plant, which had been idle since November 2008, would now be considered permanent. The company expected to service the Illinois market from its plant at Selma, MO. At the end of October, Lafarge permanently closed the kilns at its Seattle, WA, plant but announced that the facility would retain its grinding facilities, primarily to produce GGBFS from imported granules. In July, TXI announced that the wet kilns at its Midlothian, TX, plant would be closed; they had been on indefinite idle status since October 2008. The facility continued to operate its precalciner (dry) kiln. In addition to these plant closures, and as in 2009, many operating multikiln plants had one or more kilns idle for all or extended portions of 2010.

Although several plant upgrade or expansion projects remained on hold pending a recovery in cement sales, a few projects were completed in 2010. In March, Ash Grove fired its new precalciner kiln at its Foreman, AR, plant; the new kiln had an annual capacity of about 4,200 t/d and replaced the facility's three wet kilns (total capacity of 2,500 t/d) that shut down in February. The new kiln line also had new milling facilities. At its Newberry, FL, plant, Florida Rock Industries, Inc. (a subsidiary of Vulcan Materials Co.) brought a second precalciner kiln online in June. The new kiln had an annual capacity of about 0.74 Mt of clinker and was essentially identical to the existing kiln at the facility. Essroc brought a new finish mill online at its Martinsburg, WV, plant early in 2010; this followed the startup of the plant's precalciner kiln in November 2009.

Consumption

Cement consumption in the United States is reported monthly by the USGS in terms of sales to final customers, and the monthly data are summarized in table 9. Despite close agreement between the national domestic sales totals in table 9 and those in tables 11, 12, and 14, only the table 9 regional breakout tonnages represent State-level consumption. The regional breakouts in tables 11, 12, and 14 simply pertain to the locations of the reporting entities (chiefly the production sites), not the locations of consumption. It is very common for shipments to cross State lines.

In the first 2 months of the year, the U.S. cement market continued a steep decline that began in early to mid-2006; this reflected continued stagnation in most construction sectors, continued tight credit, and ongoing shortfalls in State property tax revenues. Beginning in March, however, sales of portland cement began to improve, albeit erratically and relative to the weak levels seen in 2009. Thus, although sales for 2010 overall were down by 0.5% (table 9), those for March through December were up by 3.1%. Individual State changes in sales were mixed; of the three traditionally largest consuming States (California, Florida, and Texas), only Texas showed an increase in 2010. The single largest gain in sales volumes was in Louisiana. Per-capita consumption of portland cement was 222 kg in 2010, significantly unchanged from that of 2009, and was the lowest level since 1947. By comparison, during the record consumption year of 2005, per capita consumption was 413 kg. After declining by 31% in 2009, masonry cement consumption decreased by a further 9% in 2010 to just 1.9 Mt, the lowest level since 1946.

As noted earlier, the sales data in this report are missing some imported material. An estimate of cement sales volumes by importers that do not report to the USGS can be made by comparing U.S. Census Bureau trade data (tables 17 and 21) with the USGS data for import origins of sales (table 9). The U.S. Census Bureau cement imports (including into Puerto Rico) were about 0.35 Mt higher in 2010 than the foreign origin tonnages reported to the USGS and 0.49 Mt higher than those of 2009. These differences, however, appear to underestimate the missing sales of imported cement, based on known gaps in the USGS sales data relating to the imports (table 18) from the Republic of Korea into the Philadelphia, PA, customs district and of much of the material from Colombia into the Houston, TX, Savannah, GA, and Wilmington, NC, districts. Adjusting for these, and for stockpile changes at importers, it is estimated that the annual sales tables are missing at least about 0.4 Mt of sales in 2010 and about 0.6 Mt in 2009.

Although table 9 gives the better indication of regional consumption tonnages, regional breakouts of price data (as mill net values) are listed in tables 11 and 12. Unit prices fell only modestly in 2009 despite the very large decrease in sales volumes, but in 2010, prices for portland cement fell significantly almost everywhere in the country. Price changes commonly lag changes in sales volumes because of the common existence of long-term pricing contracts, and prices in 2010 appeared to have "caught up" to the oversupply of cement on the market. Price shifts for masonry cement (table 13) are difficult to evaluate because of the high but variable percentage of sales that are in bag or package form rather than the much cheaper bulk form; the split between bag and bulk sales is not reported to the USGS.

Table 10 lists sales of portland cement by mode of transportation. The major change evident was that a higher percentage of sales in 2010 were directly at or from the cement plants (as opposed to from terminals) than was the case in 2009.

Cement consumption levels within a given category of construction broadly reflect levels of construction spending, although significant time lags may exist between the onset or cutoff of spending and changes in the consumption of cement. In terms of 1996 constant dollars, overall construction spending in 2010 fell by nearly 9% to $503 billion (Portland Cement Association, 2012). Of this total, public sector construction was the largest share, at $182 billion, down by 2%, but included spending for road construction that increased by nearly 3%. Residential construction, the second largest sector, was essentially stagnant at about $164 billion; within this sector, single-family construction spending increased by nearly 9%, and multifamily construction spending decreased by nearly 50%. Nonresidential construction spending decreased by nearly 29% to about $94 billion.

A breakout of 2010 portland cement sales by customer type is provided in table 14. Sales to ready-mixed concrete producers accounted for 69% of total shipments, but the true percentage to this type of customer was larger because some of the sales were reported under other customer categories, such as road paving contractors, that also make use of ready-mixed concrete. As listed, the sales to ready-mixed customers fell by 3.7%, but if combined with airport and road paving contractors (to better approximate true sales into the ready-mixed sector), the decline was just 1.9%. Within the contractor sales category, overall sales for road paving increased by nearly 28%, considerably higher than the overall spending increase noted above, and suggestive of a possible gain in concrete's market share in that subsector. Sales to brick and block makers declined by nearly 11%, and sales to precast and prestressed slab makers decreased by about 4%. Sales to oil (and gas) well drilling companies were up by 55%, in line with increased oil and gas prices during the year, and presumably would have been higher if there had not been a 6-month moratorium on offshore drilling in 2010.

Sales of various types included as portland cement by the USGS are broken out in table 15. As in past years, sales were dominated by Types I and II cements and sulfate-resistant varieties of cement (Type V and Type II/V hybrids reported as Type V); these also included equivalent cements sold under the specifications of ASTM C–1157. Most of the decline in sales in 2010 was in the Types I and II grouping. Oil-well cement sales were up, as noted above. White cement sales increased by about 11%. Unlike the case in recent years, the white cement sales tonnage in 2010 was significantly higher than the imports of white cement (table 20). The relationship of white cement sales and imports has always been complicated by the use of some white cement in masonry cement (sales of which are not included in table 15), in colored cements that may have been reported with the gray varieties, and by the fact that some imported white cement is blended with domestically produced white cement. Because of the relatively low overall tonnages involved, sales versus imports of white cement may be particularly sensitive to changes in stockpile tonnages.

Blended cement sales were up by nearly 21%, especially of varieties containing GGBFS. As in 2009, the overall tonnage of blended cement sales in 2010 was significantly lower than the nearly 2.0 Mt listed in the monthly sales data for the year. It remains uncertain why this difference exists, but it most likely relates to continued inconsistencies in characterizing cement sold under the general performance standard ASTM C–1157, which at one time applied only to blended cements but which now applies to hydraulic cements in general.

Foreign Trade

Trade data supplied by the U.S. Census Bureau are listed in tables 16–21. Exports (table 16) increased by about one-third in 2010 to nearly 1.2 Mt. Although this was the highest level in more than 60 years, exports remained a very small part of total sales by the U.S. industry and continued to be small compared to cement imports. Canada was the main destination for U.S. exports, accounting for 69% of the total.

Total imports of cement and clinker in 2010 fell slightly to 6.6 Mt (tables 1, 17), continuing, but at a much slower rate, a trend of decline since the record importation year of 2006 (35.6 Mt). As usual, most of the imports were of gray portland cement, and most of the decline in imports was of material from Colombia and Turkey. Imports from most other countries increased (table 19). As in 2009, Canada remained by far the leading source of cement imports. Imports from Asian countries, although growing slightly in 2010, had yet to even remotely recover their dominance of former years (such as 54% of total imports in 2006).

Official imports of white cement are listed in table 20. In many past years, and based on unexpectedly low unit values, the data appeared to have included some gray cement or clinker; the apparent errors were because of the use of the wrong tariff code by importers. For 2010, the average unit value for imports from China indicates the possible inclusion of some tonnage of gray cement. For 2009, the value data for the Republic of Korea suggest that most of the material was gray cement.

Imports of clinker increased by 10% to 0.61 Mt (table 21), but the data are incomplete with regard to overland imports from Canada; the tonnages listed are insufficient to have fully supplied the three grinding plants in Michigan and Washington. The annual deficit is estimated to be about 0.2 Mt in both 2009 and 2010. The unreported Canadian clinker appears mostly to have come in by truck, at a value of less than $2,000 (customs value) per truckload; such shipments are classified as "informal entries" and data on them are not routinely transmitted by the U.S. Customs Service to the U.S. Census Bureau for recordation into the official trade data (reproduced in tables 17–21). This problem presumably does not exist for imports by rail or by ship because these shipments are larger.

For cement and clinker combined, the 10 busiest customs districts of entry in 2010 were, in descending order of tonnage, Detroit, MI; Seattle, WA; Houston-Galveston, TX; Buffalo, NY; Cleveland, OH; Columbia-Snake, ID, OR, and WA; Honolulu, HI; El Paso, TX; New York, NY; and San Francisco, CA (table 18). These leading districts accounted for about 72% of the total imports for the year.

World Review

World hydraulic cement production data are listed in table 22. The data are intended to include all forms of hydraulic cement; however, the data for the United States are for portland and masonry cement only and data for some other countries may be incomplete. For some countries, the production data may include exports of clinker.

World cement output in 2010 was an estimated 3.31 Gt, up by about 9%. Production was from more than 150 countries. China was again the world's leading producer by far, with an output of 1.88 Gt or nearly 57% of the world total.

The remaining top 20 producers in 2010 were, in descending order of tonnage, India, the United States, Turkey, Brazil, Japan, Russia, Iran, Vietnam, Egypt, the Republic of Korea, Saudi Arabia, Thailand, Italy, Mexico, Pakistan, Germany, Spain, Indonesia, and Algeria. Cumulatively, the top 5 countries accounted for 69% of total world output; the top 10 countries, about 76%; and the top 20 countries, about 86%.

Regionally, Asia and the Pacific contributed nearly 73% of world production, including 9 of the 20 leading producing countries, and had the highest growth rate of all regions; the region had accounted for 58% of world output in 2000 and 65% in 2005. Because of this rapid growth in Asia (particularly in China), most other regions, although increasing output tonnage, have had generally diminishing shares of total world output. For example, North America (including Mexico) contributed 8% of world output in 2000 and 6.5% in 2005 but only 3.5% in 2010. Central and South America (including the Caribbean) accounted for about 5% of world production in 2000 but less than 4% in 2010. Western Europe contributed 12% of world output in 2000 but only 9% in 2005 and just 5% in 2010. Eastern Europe produced nearly 2% of world output in 2000 but just 1.4% in 2010. Other regions have held fairly constant world shares during the past decade, at about 4% for Africa, nearly 7% for the Middle East, and about 3% for the Commonwealth of Independent States.

Outlook

The general increase in cement sales that began in March 2010 was expected to continue in 2011, with sales for 2011 anticipated to be about 3% higher for the year and with further modest increases expected for the next few years thereafter. High rates of growth were not expected until the housing market and tax revenues to States recovered significantly. Absent improvement to the latter, State contributions to public sector construction projects would likely continue to be hampered.

Given the significant underutilization of production capacity in 2010, domestic production normally would be favored instead of imports to meet all or most increases in short-term cement demand. However, given that much of the underutilized capacity was in the form of year- or multiyear-long idlings of extra kilns (or even of entire plants), and because many of the idle kilns were old or of energy-inefficient technology, many of the older facilities may be unable to meet or justify upgrades to meet NESHAP emissions limits. Because many plants have experienced significant and extended layoffs of personnel, it was unclear how quickly domestic production could recover should demand increase faster than expected. Thus, while imports were not expected to increase in 2011, these production-related issues offered the possibility of imports gaining market share in the medium term. In the long-term, should the cement market recover to high (such as 2005) consumption levels, and if NESHAP or other new regulations lead to a large number of plant closures, it is unclear if current importation capacity will be adequate to compensate for the production shortfalls.

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TABLE 1
SALIENT CEMENT STATISTICS FOR THE UNITED STATES[1, 2]

(Thousand metric tons unless otherwise specified)

	2006	2007	2008	2009	2010
Production:					
Cement[3]	98,167	95,464	86,310	63,907 [r]	66,421
Clinker	88,555	86,130	78,382	56,116	59,802
Shipments from mills and terminals:[3, 4, 5]					
Quantity	127,000	114,000	96,700	71,000 [r]	70,300
Value[6] thousand dollars	12,900,000	11,900,000	9,990,000	7,020,000	6,470,000
Average value[6] dollars per metric ton	101.50	104.00	103.50	99.00	92.00
Stocks, yearend:					
Cement	9,380	8,890	8,360	6,080	6,180
Clinker	5,370	6,550	7,070	5,130	4,760
Exports	723 [7]	886 [7]	823	884	1,178
Imports:[8]					
Cement	32,141	21,496	10,744	6,211	6,013
Clinker	3,425	972	621	556	613
Total[9]	35,566	22,468	11,365	6,767	6,626
Consumption, apparent[10]	127,660	116,550	96,760	71,510 [r]	71,160
World production[e, 11]	2,620,000 [r]	2,810,000	2,850,000	3,030,000 [r]	3,310,000

[e] Estimated. [r] Revised.

[1] Unless otherwise indicated, data are for portland (including blended) and masonry cements only. Even where presented unrounded, data are thought to be accurate to no more than three significant digits.

[2] Excludes Puerto Rico.

[3] Includes cement made from imported clinker. Includes a double-counted component (less than 0.3% per year) of portland cement subsequently converted by the cement plants to masonry cement; because of the involvement of stockpiles, the precise amount converted from actual production cannot be determined.

[4] Includes imported cement.

[5] Shipments to final domestic customers. Data are from an annual survey of plants and terminals and may differ from the totals in table 9, which are based on consolidated monthly surveys from companies.

[6] Value free on board mill or independently reporting terminal.

[7] Official export data have been corrected to remove an apparent excess of aluminous cement from Laredo, TX, of 943,939 metric tons in 2006 and 653,255 metric tons in 2007.

[8] All forms of hydraulic cement or clinker.

[9] Data may not add to totals shown because of independent rounding.

[10] Production (including that from imported clinker) of cement plus imports of hydraulic cement minus exports of hydraulic cement minus the change in yearend cement stocks.

[11] Total hydraulic cement. May include clinker exports for some countries.

TABLE 2
COUNTY BASIS OF SUBDIVISION OF STATES IN CEMENT TABLES

State subdivision	Defining counties
California, northern	Alpine, Fresno, Kings, Madera, Mariposa, Monterey, Tulare, Tuolumne, and all counties farther north.
California, southern	Inyo, Kern, Mono, San Luis Obispo, and all counties farther south.
Illinois, metropolitan Chicago	Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will Counties in Illinois.
Illinois, excluding Chicago	All counties other than those in metropolitan Chicago.
New York, eastern	Delaware, Franklin, Hamilton, Herkimer, Otsego, and all counties farther east and south, except those within Metropolitan New York.
New York, western	Broome, Chenango, Lewis, Madison, Oneida, St. Lawrence, and all counties farther west.
New York, metropolitan	New York City (Bronx, Kings, New York, Queens, and Richmond), Nassau, Rockland, Suffolk, and Westchester.
Pennsylvania, eastern	Adams, Cumberland, Juniata, Lycoming, Mifflin, Perry, Tioga, Union, and all counties farther east.
Pennsylvania, western	Centre, Clinton, Franklin, Huntingdon, Potter, and all counties farther west.
Texas, northern	Angelina, Bell, Concho, Crane, Culberson, El Paso, Falls, Houston, Hudspeth, Irion, Lampasas, Leon, Limestone, McCulloch, Reagan, Reeves, Sabine, San Augustine, San Saba, Tom Green, Trinity, Upton, Ward, and all counties farther north.
Texas, southern	Brazos, Burnet, Crockett, Jasper, Jeff Davis, Llano, Madison, Mason, Menard, Milam, Newton, Pecos, Polk, Robertson, San Jacinto, Schleicher, Tyler, Walker, Williamson, and all counties farther south.

TABLE 3
PORTLAND AND BLENDED CEMENT PRODUCTION, CAPACITY, AND STOCKS IN THE UNITED STATES, BY DISTRICT [1]

(Thousand metric tons unless otherwise specified)

	2009					2010				
District[2]	Number of plants	Production	Grinding capacity[3]	Percentage utilized[4]	Yearend stocks[5]	Number of plants	Production	Grinding capacity[3]	Percentage utilized[4]	Yearend stocks[5]
Maine and New York	5	2,118	4,341	49	219 [6]	5	2,122	4,236	50	198
Pennsylvania, eastern	7	3,042 [r]	5,420 [6]	57	247	7	3,382 [7]	6,790 [6, 7]	50 [6, 7]	346 [7]
Pennsylvania, western	3	678	1,805	38	103	2	W [7]	W [7]	W [7]	W [7]
Illinois	3	1,487	3,390	44	237	3	1,620	2,755	59	235
Indiana	4	2,685	3,740 [6]	72	188	4	2,473	3,745	66	219
Michigan	5	3,548	6,983	51	163	4	3,482	5,530	63	230
Ohio	2	550	1,166	47	25	2	627	1,166	54	56
Iowa, Nebraska, South Dakota	5	2,991	5,840 [6]	51	266	5	2,677	5,840 [6]	46 [6]	257
Kansas	3	1,669	2,940 [6]	57	166	3	1,824	2,937	62	240
Missouri	6	4,418	13,035	34	622	5	6,469	10,817	60	661
Florida[8]	7	3,145	7,610 [6]	41	260	7	3,354	9,380 [6]	36 [6]	306
Georgia, Maryland, Virginia, West Virginia	6	3,859	7,180 [6]	54	334	6	4,305	7,906	54	418
South Carolina	3	1,868	5,085	37	77	3	2,048	5,085	40	114
Alabama	5	3,416	7,292	47	231 [6]	5	3,286	7,292	45	266
Kentucky, Mississippi, Tennessee	4	1,958	3,702	53	147	4	2,193	3,702	59	268
Arkansas and Oklahoma	4	2,067	3,127	66	182	4	2,012	4,078	49	165
Texas, northern	6	3,833	7,580 [6]	51	609	6	3,867	7,765	50	176
Texas, southern	6	4,519	6,505	69	226 [6]	6	5,000	6,185	81	214
Arizona and New Mexico	3	1,464	3,116	47	91	3	1,244	3,116	40	98
Colorado and Wyoming	4	2,165	4,517	48	149	4	2,333	4,517	52	114
Idaho, Montana, Nevada, Utah	6	2,050	3,728	55	156	6	2,055	3,725	55	146
Alaska and Hawaii	--	--	--	--	55	--	--	--	--	66
California	11	7,153	13,600 [6]	53	417 [6]	10	6,945	12,851	54	422 [6]
Oregon and Washington	4	1,254	2,435	51	275 [6]	4	1,200	2,435	49	269
Importers[9]	--	--	--	--	182 [6]	--	--	--	--	269 [6]
Total[10]	112	61,939 [r, 11]	124,000 [6]	50	5,620 [6]	108	64,520 [11]	122,000 [6]	53	5,750 [6]
Puerto Rico	2	936	1,780	53	47 [6]	2	755	1,780	42	49
Grand total[10]	114	62,875 [r, 11]	126,000 [6]	50	5,670 [6]	110	65,275 [11]	124,000 [6]	53	5,800 [6]

[r] Revised. W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

[1] Even where presented unrounded, data are thought to be accurate to no more than three significant digits. Includes data for white cement. Includes cement made from imported clinker.

[2] District assignation is the location of the reporting facilities. Specific districts include importers for which district assignations were possible.

[3] Grinding capacity is based on fineness needed to produce a plant's normal output mix, including masonry cement, and allowing for downtime for routine maintenance.

[4] Calculated relative to portland cement output; utilization would be higher if calculated to include output of masonry cement.

[5] Includes imported cement. Includes stocks at mills, terminals, and in transit.

[6] Data contain estimates for nonrespondents or incompletely reporting facilities.

[7] For 2010, data for Western Pennsylvania are included with those for Eastern Pennsylvania.

TABLE 3—Continued
PORTLAND AND BLENDED CEMENT PRODUCTION, CAPACITY, AND STOCKS IN THE UNITED STATES, BY DISTRICT[1]

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[8] Production and capacity data exclude a plant that produced only masonry cement.

[9] Data include only those importers or terminals for which district assignations were not possible.

[10] Data may not add to totals shown because of independent rounding.

[11] The production totals include a small amount of portland cement subsequently consumed to make masonry cement; the amount thus double-counted cannot be determined precisely because of the involvement of stockpiles, but is less than 0.5% of the totals listed.

TABLE 4

MASONRY CEMENT PRODUCTION AND STOCKS IN THE UNITED STATES, BY DISTRICT[1]

(Thousand metric tons unless otherwise specified)

	2009			2010		
District[2]	Number of active plants	Production[3]	Yearend stocks[4]	Number of active plants	Production[3]	Yearend stocks[4]
Maine and New York	4	41	12	4	40	14
Pennsylvania	9	176	46	8	147	41
Indiana and Ohio	6	244	52	6	260	59
Michigan	4	80	28	3	83	24
Iowa, Nebraska, South Dakota	2	W	W	1	W	W
Kansas	2	W	W	2	W	W
Missouri	1	W	W	1	W	W
Florida	6	123	38	6	198	42
Georgia, Maryland, Virginia, West Virginia	6	250	42	6	251	42
South Carolina	3	174	16	3	152	17
Alabama	4	208	61	4	191	47
Kentucky, Mississippi, Tennessee	3	W	W	3	W	W
Arkansas and Oklahoma	3	97	21	4	92	17
Texas	8	202	22	8	199	22
Arizona and New Mexico	3	W	W	3	W	W
Colorado and Wyoming	2	W	W	2	W	W
Idaho, Montana, Nevada, Utah	--	W	W	1	W	W
California	7	236	45 [5]	6	178	32 [5]
Importers[6]	--	--	3 [5]	--	--	9 [5]
Total[7]	73	1,968	456 [5]	71	1,901	427 [5]

W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

[1] Includes masonry, portland-lime, plastic, and stucco cements. Even where presented unrounded, data are thought to be accurate to no more than three significant digits.

[2] District assignation is the location of the reporting facilities. Specific districts include importers for which district assignations were possible.

[3] Includes cement produced from imported clinker.

[4] Includes imported cement.

[5] Data contain estimates for nonrespondents or incompletely reporting facilities.

[6] Data include only those importers or terminals for which district assignations were not possible.

[7] Data may not add totals shown because of independent rounding.

TABLE 5

CLINKER CAPACITY AND PRODUCTION IN THE UNITED STATES IN 2010, BY DISTRICT[1]

District	Number of active plants[2]				Number of kilns[4]	Daily capacity[4, 5] (thousand metric tons)	Average days of routine maintenance[6]	Apparent annual capacity[4, 7] (thousand metric tons)	Production (thousand metric tons)	Percentage of capacity utilized	Yearend stocks (thousand metric tons)
	Process used										
	Wet	Dry	Both[3]	Total							
Maine and New York	2	2	--	4	5	11.3	32.8	3,748	1,971	52.6	115
Pennsylvania	2	6	--	8	14	19.2	18.9 [8]	6,500 [8]	3,198	49.2 [8]	244
Illinois	--	3	--	3	6	7.7	10.9	2,677	1,474	55.0	122
Indiana	1	3 [9]	--	4	8	10.2	21.1 [8]	3,470 [8]	2,326	67.1 [8]	108
Michigan	--	2	--	2	6	11.2	32.3	3,679	2,703	73.5	159
Ohio	1	1	--	2	3	3.4	9.7	1,202	680	56.6	89
Iowa, Nebraska, South Dakota	--	4	1	5	9	14.1	15.7 [8]	4,870 [8]	2,351	48.3 [8]	131
Kansas	1	2	--	3	5	8.5	21.6	2,956	1,937	65.5	90
Missouri	--	5	--	5	5	28.5	30.0 [8]	9,620 [8]	5,909	62.1 [8]	340
Florida	--	7	--	7	10	25.9 [8]	15.3 [8]	9,090 [8]	3,303	36.3 [8]	394
Georgia, Maryland, Virginia, West Virginia	--	5	--	5	5	19.5	29.6 [8]	6,500 [8]	4,090	63.0 [8]	264
South Carolina	--	3	--	3	3	12.3	26.8	4,180	1,906	45.6	265
Alabama	--	5	--	5	5	16.9	21.0 [8]	5,790 [8]	3,185	55.0 [8]	223
Kentucky, Mississippi, Tennessee	1	3	--	4	4	11.0	15.5 [8]	3,810 [8]	2,193	57.6 [8]	134
Arkansas and Oklahoma	1	2	1	4	11	12.5	24.9	4,125	1,803	43.7	105
Texas, northern	2	4 [10]	(10)	6	12	19.0	23.2	6,552	3,374	51.5	383
Texas, southern	--	5	--	5	6	16.2	19.4	5,606	4,536	80.9	222
Arizona and New Mexico	--	3	--	3	7	8.6	3.6	3,091	1,205	39.0	174
Colorado and Wyoming	--	4	--	4	5	11.5	27.5	3,829	2,162	56.5	252
Idaho, Montana, Nevada, Utah	3	3	--	6	8	8.5	22.9 [8]	2,880 [8]	1,770	61.6 [8]	174
California	--	9	--	9	11	37.9 [8]	17.9	12,900 [8]	6,634	51.2	734
Oregon and Washington	1	2	--	3	3	6.0	30.0	2,033	1,091	53.6	47
Total[11]	15	83	2	100	151	321.0 [8]	20.8 [8]	109,000 [8]	59,802	54.8 [8]	4,760
Puerto Rico	--	2	--	2	2	5.3	42.5 [8]	1,730 [8]	642	37.1 [8]	64
Grand total[11]	15	85	2	102	153	326.0 [8]	21.0 [8]	111,000 [8]	60,444	54.6 [8]	4,830

-- Zero.

[1] Even where presented unrounded, data are thought to be accurate to no more than three significant digits.

[2] Includes white cement plants. Includes all plants that produced clinker for at least 1 day during the year.

[3] Plants that can operate both wet and dry kilns, whether or not both types were active during the year.

[4] Includes kilns active for at least 1 day during the year. For kilns idle all year, excludes those that cannot be restarted, fully permitted, in less than 6 months.

[5] Sum of reported kiln capacities for all plants in a district.

[6] Total days of routine maintenance (summed for all kilns) divided by the number of kilns.

[7] Sum of apparent annual capacities for all kilns. For each kiln, the statistic is calculated as 365 days minus days reported for routine maintenance and then multiplied by the unrounded daily capacity.

[8] Data contain estimates for nonrespondents and incompletely reporting facilities and have been rounded to no more than three significant digits.

[9] Includes one semiwet kiln.

[10] Includes as a dry operation one plant, formerly operating both wet and dry kilns, whose wet kilns were idle all year (2009) and which, in 2010, were declared permanently closed.

[11] Data may not add to totals shown because of independent rounding.

TABLE 6

RAW MATERIALS USED TO PRODUCE CLINKER AND CEMENT IN THE UNITED STATES[1, 2]

(Thousand metric tons)

Materials	2009		2010	
	Clinker	Cement[3]	Clinker	Cement[3]
Calcareous:				
Limestone (aragonite, chalk, coral, marble)	73,600	1,510	78,500	1,550
Cement rock (includes marl)	6,560	--	7,500	30
Cement kiln dust (CKD)[4]	288	156	256	141
Lime[4]	17	5	20	17
Other	62	--	47	13
Aluminous:				
Clay	2,500	3	2,830	--
Shale and schist	2,540	--	2,370	13
Other[5]	438	--	478	--
Ferrous:				
Iron ore	481	--	501	--
Mill scale	536	--	522	--
Other[6]	40	--	19	--
Siliceous:				
Sand, calcium silicates	2,550	--	2,830	--
Sandstone, quartzite, soils, nonpozzolanic rocks	464	--	506	--
Fly ash	2,290	74	2,430	85
Other ash, including bottom ash	706	--	727	--
Granulated blast furnace slag[7]	44	192	70	235
Other blast furnace slag	99	--	30	--
Steel slag	169	--	238	--
Other slag	38	--	165	2
Natural rock pozzolans[8]	--	11	--	20
Other pozzolans[9]	45	3	9	1
Other:				
Gypsum and anhydrite	(10)	3,367	(10)	3,550
Other[11]	79	57	62	61
Total[12]	93,600	5,380	100,000	5,720
Clinker, imported, raw materials equivalent[13]	--	1,250	--	1,190
Grand total[12]	93,600	6,630	100,000	6,910

-- Zero.

[1] Excludes Puerto Rico.

[2] Data have been rounded to three significant digits to reflect inherent reporting accuracy and the incorporation of estimates for some facilities.

[3] Includes portland, blended, and masonry cements.

[4] Data are probably underreported.

[5] Includes alumina, aluminum dross, bauxite, spent catalysts, and other aluminous materials.

[6] Includes iron sludges, pyrite, and other ferrous materials.

[7] Includes both ground (GGBFS) and unground material.

[8] Includes pozzolana and burned clays or shales (except where directly reported as clay or shale).

[9] Includes diatomite, silica fume, other microcrystalline silica, and other pozzolans, even if not used as such.

[10] Included with Calcareous: Other.

[11] Includes fluorspar and all other materials not listed earlier.

[12] Data may not add to totals shown because of independent rounding.

[13] Converted as 1.7 times the weight of foreign clinker consumed.

TABLE 7
CLINKER PRODUCED AND FUEL CONSUMED BY THE U.S. CEMENT INDUSTRY, BY KILN PROCESS[1]

	Clinker production[2]			Conventional fuels[3]				Waste fuels[3]		
Kiln process	Number of plants	Quantity (thousand metric tons)	Percentage of total	Coal[4] (thousand metric tons)	Petcoke (thousand metric tons)	Oil[5] (thousand liters)	Natural gas[6] (thousand cubic meters)	Tires (thousand metric tons)	Solid (thousand metric tons)	Liquid (thousand liters)
2009:										
Wet	19	4,866	8.7	569	157	7,310	96,200	50	16	256,000
Dry[7]	81	50,112	89.3	4,690	1,300	26,500	247,000	263	307	493,000
Both[8]	3	1,138	2.0	186	33	1,810	1,190	--	--	34,600
Total[9]	103	56,116	100.0	5,450	1,490	35,600	344,000	313	324	784,000
2010:										
Wet	15	3,918	6.6	498	148	6,480	27,200	52	59	229,000
Dry[7]	83	54,600	91.3	5,110	1,320	24,100	252,000	270	351	639,000
Both[8]	2	1,285	2.1	194	--	--	7,260	--	--	41,300
Total[9]	100	59,802	100.0	5,810	1,470	30,500	287,000	322	411	909,000

-- Zero.

[1] Excludes Puerto Rico.

[2] Clinker production data are all reported. Although unrounded, data are thought to be accurate to no more than three significant digits.

[3] All fuel data have been rounded to no more than three significant digits.

[4] All reported to be bituminous.

[5] Distilliate and residual fuel oils. Excludes used oils that were reported under liquid wastes.

[6] Includes landfill gas and propane.

[7] Includes one semiwet plant. Also includes one plant that operated a dry kiln, but also had wet kilns which, although technically idle all year, were officially closed in 2010.

[8] Plants that can operate both wet and dry kilns, whether or not both types were active during the year. Includes plants that converted from wet to dry technology during the year. Excludes one plant as noted in footnote 7.

[9] Data may not add to totals shown because of independent rounding.

TABLE 8
ELECTRICITY CONSUMED BY U.S. CEMENT PLANTS, BY KILN PROCESS [1]

Plant process	Electricity consumed[2]							Cement produced[4] (thousand metric tons)	Average consumption (kilowatthours per ton of cement produced)
	Generated		Purchased		Total[3]				
	Number of plants	Quantity (million kilowatthours)	Number of plants	Quantity (million kilowatthours)	Number of plants	Quantity (million kilowatthours)	Percentage of total		
2009:									
Integrated plants:									
Wet	--	--	19	815	19	815	8.8	5,804	140
Dry[5]	2	223	83 [6]	7,980	83 [6]	8,200	88.6	55,601	148
Both[7]	--	--	3	222	3	222	2.4	1,334	166
Total or average[3]	2	223	105 [6]	9,020	105 [6]	9,250	100.0	62,738	147
Grinding plants[8]	--	--	6	103	5 [r]	103	--	1,047	99
Exclusions[9]	--	--	3	XX	3	XX	--	143	XX
2010:									
Integrated plants:									
Wet	--	--	15	621	15	621	6.5	4,277	145
Dry[5]	3	226	85 [6]	8,470	85 [6]	8,700	91.3	59,654	146
Both[7]	--	--	2	205	2	205	2.2	1,377	149
Total or average[3]	3	226	102 [6]	9,300	102 [6]	9,520	100.0	65,309	146
Grinding plants[8]	--	--	4	96	4	96	--	965	100
Exclusions[9]	--	--	3	XX	3	XX	--	147	XX

[r] Revised. XX Not applicable. -- Zero.

[1] Excludes Puerto Rico.

[2] Electricity data are rounded to no more than three significant digits because they contain estimates.

[3] Data may not add to totals shown because of independent rounding.

[4] Portland and masonry cement. Data are all reported and are unrounded.

[5] Includes one plant that operated a dry kiln but that had wet kilns which, although technically idle all year, were officially closed early in 2010.

[6] Includes two grinding plants whose data were included with the integrated plants.

[7] Plants that can operate both wet and dry kilns, whether or not both types were active during the year. Includes plants that converted from wet to dry technology during the year. Excludes one plant as noted in footnote 5.

[8] Plants that did not produce clinker but ground clinker from outside sources. Excludes plants that only made masonry cement or just reground one type of portland cement into another, or which also reported a substantial component of grinding of excess granulated blast furnace slag.

[9] Plants at which production of portland cement was by simply regrinding of one type into another, or which reported production only of masonry cement.

TABLE 9

CEMENT SHIPMENTS TO FINAL CUSTOMER, BY DESTINATION AND ORIGIN[1, 2]

(Thousand metric tons)

Destination and origin	Portland cement		Masonry cement	
	2009	2010	2009	2010
Destination:				
Alabama	1,140	1,009	85	77
Alaska[3]	146	137	--	--
Arizona	1,727	1,477	26	22
Arkansas	732	757	40	38
California, northern	2,133	2,081	45	35
California, southern	4,395	4,137	170	145
Colorado	1,403	1,467	7	6
Connecticut[3]	478	469	11	11
Delaware[3]	159	172	5	4
District of Columbia[3]	129	109	(4)	(4)
Florida	3,946	3,486	231	211
Georgia	1,887	1,685	131	116
Hawaii[3]	306	262	2	3
Idaho	367	387	(4)	(4)
Illinois, excluding Chicago	1,397	1,413	10	10
Illinois, metropolitan Chicago[3]	1,181	1,020	19	14
Indiana	1,454	1,482	39	34
Iowa	1,448	1,431	1	1
Kansas	1,133	1,172	7	5
Kentucky	870	852	49	45
Louisiana[3]	2,135	2,742	49	48
Maine	185	185	2	2
Maryland	902	888	42	42
Massachusetts[3]	702	679	11	10
Michigan	1,384	1,554	42	40
Minnesota[3]	1,135	1,200	12	12
Mississippi	805	774	40	39
Missouri	1,728	1,563	19	17
Montana	256	259	1	(4)
Nebraska	1,018	988	2	1
Nevada	1,008	897	12	6
New Hampshire[3]	198	185	7	7
New Jersey[3]	1,152	1,123	43	40
New Mexico	534	604	7	4
New York, eastern	476	456	10	9
New York, western[3]	652	657	16	14
New York, metropolitan[3]	1,304	1,189	59	50
North Carolina[3]	1,612	1,581	135	127
North Dakota[3]	375	408	1	1
Ohio	2,232	2,352	78	71
Oklahoma	1,338	1,432	39	39
Oregon	663	609	(4)	(4)
Pennsylvania, eastern	1,270	1,436	37	37
Pennsylvania, western	913	979	33	32
Rhode Island[3]	106	93	1	1
South Carolina	822	931	70	61
South Dakota	450	447	1	(4)
Tennessee	1,223	1,230	108	103
Texas, northern	4,255	4,713	79	73
Texas, southern	5,344	5,392	157	153
Utah	1,058	1,023	(4)	(4)

See footnotes at end of table.

TABLE 9—Continued

CEMENT SHIPMENTS TO FINAL CUSTOMER, BY DESTINATION AND ORIGIN[1, 2]

(Thousand metric tons)

Destination and origin	Portland cement 2009	Portland cement 2010	Masonry cement 2009	Masonry cement 2010
Destination—Continued:				
Vermont[3]	95	103	2	1
Virginia	1,526	1,368	80	76
Washington	1,437	1,322	1	(4)
West Virginia	402	426	14	12
Wisconsin[3]	1,410	1,431	10	9
Wyoming	348	322	(4)	(4)
Total[5]	68,885	68,544	2,102	1,913
Puerto Rico	979	808	(4)	3
Foreign countries[6]	502	707	(4)	(4)
Grand total[5]	70,366	70,059	2,102	1,918
Origin:				
United States	63,486	63,627	2,070	1,897
Puerto Rico	932	731	--	(4)
Foreign countries[7]	5,948	5,701	32	21
Total shipments[5]	70,366	70,059	2,102	1,918

-- Zero.

[1] Includes cement produced from imported clinker and imported cement shipped by domestic producers and importers.

[2] Data are developed from consolidated monthly surveys of shipments by companies and may differ from data in tables 1, 10–12, and 14–15, which are from annual surveys of individual plants and importers. Although presented unrounded, data are thought to be accurate to no more than three significant digits.

[3] Has no cement plants.

[4] Less than ½ unit.

[5] Data may not add to totals shown because of independent rounding.

[6] Includes shipments to U.S. possessions and territories.

[7] Imported cement sold to final customers in the United States as reported by domestic producers and other importers. Data do not match the imports in tables 17–20.

TABLE 10

SHIPMENTS OF PORTLAND CEMENT IN THE UNITED STATES, BY TYPE OF CARRIER[1,2]

(Thousand metric tons)

	Plant to terminal		Plant to customer		Terminal to customer		Total to customers[4]
	In bulk	In bags[3]	In bulk	In bags[3]	In bulk	In bags[3]	
2009:							
Railroad	9,580	8	1,460	2	528	4	2,000
Truck	4,000	116	36,000	1,040	29,400	400	66,900
Barge and boat	7,120	--	55	--	--	--	55
Total[4]	20,700	125	37,500	1,040	29,900 r	404	68,900 r, 5
2010:							
Railroad	8,980	6	1,660	10	467	4	2,140
Truck	3,570	83	37,600	966	27,200	307	66,100
Barge and boat	6,270	15	67	--	93	58	218
Total[4]	18,800	105	39,300	977	27,800	370	68,400 5

[r] Revised. -- Zero.

[1] Includes imported cement and cement made from imported clinker. Excludes Puerto Rico.

[2] Data are rounded to no more than three significant digits because they contain estimates.

[3] Includes packages, bags, and supersacks.

[4] Data may not add to totals shown because of independent rounding.

[5] Shipments are based on an annual survey of plants and importers; may differ from totals in table 9, which are based on consolidated monthly data.

TABLE 11

PORTLAND CEMENT SHIPPED IN THE UNITED STATES, BY DISTRICT[1]

	2009			2010		
		Value[2]			Value[2]	
District[4]	Quantity[3] (thousand metric tons)	Total (thousands)	Average (per metric ton)	Quantity[3] (thousand metric tons)	Total (thousands)	Average (per metric ton)
Maine and New York	2,560 [r, 5]	$248,000 [r, 5]	$97.00 [5]	2,459	$225,563	$91.72
Pennsylvania, eastern	2,995	285,000 [5]	95.00 [5]	3,887 [6]	369,000 [5, 6]	95.00 [5, 6]
Pennsylvania, western	949	90,800 [5]	95.50 [5]	W [6]	W [6]	W [6]
Illinois	2,014	191,586	95.11	2,016	179,580	89.07
Indiana	1,951	169,069	86.66	1,907	153,623	80.55
Michigan	4,114	406,143	98.72	3,920 [5]	393,000 [5]	100.50 [5]
Ohio	582	55,691	95.69	598	55,111	92.18
Iowa, Nebraska, South Dakota	3,382	365,298	108.01	3,017	311,194	103.13
Kansas	1,627	166,000 [5]	102.00 [5]	1,596	155,919	97.66
Missouri	4,219	414,000 [5]	98.00 [5]	6,253	517,000 [5]	82.50 [5]
Florida	3,790 [5]	371,000 [5]	98.00 [5]	3,260 [5]	295,000 [5]	90.50 [5]
Georgia, Maryland, Virginia, West Virginia	4,141	367,335	88.70	3,978	334,768	84.16
South Carolina	1,826	165,160	90.46	1,894	164,338	86.78
Alabama	3,515	315,408	89.72	3,024	252,000 [5]	83.00 [5]
Kentucky, Mississippi, Tennessee	1,885	187,660	99.53	1,740	162,965	93.65
Arkansas and Oklahoma	2,300	231,363	100.60	2,254	219,468	97.38
Texas, northern	4,557	453,000 [5]	99.50 [5]	4,511	412,000 [5]	91.00 [5]
Texas, southern	4,730	452,380	95.65	5,300	455,862	86.01
Arizona and New Mexico	2,173	255,708	117.68	1,786	182,539	102.20
Colorado and Wyoming	1,932	190,508	98.63	2,090 [5]	194,000 [5]	93.00 [5]
Idaho, Montana, Nevada, Utah	2,063	199,834	96.87	1,971	182,061	92.36
Alaska and Hawaii	406	66,690	164.27	357	57,700 [5]	162.00 [5]
California	6,835	618,000 [5]	90.50 [5]	6,880 [5]	543,000 [5]	79.00 [5]
Oregon and Washington	1,651	150,011	90.85	1,244	111,988	90.05
Importers[7]	2,747	315,000 [5]	115.00 [5]	2,480 [5]	289,000 [5]	116.50 [5]
Total or average[8]	68,900 [r, 5]	6,730,000 [5]	97.50 [5]	68,400 [5]	6,220,000 [5]	91.00 [5]
Puerto Rico	978 [5]	W	W	830	W	W
Grand total[8]	69,900 [5]	W	W	69,300 [5]	W	W

[r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Includes gray and white portland cement. Includes cement made from imported clinker. Even where presented unrounded, data are thought to be accurate to no more than three significant digits.

[2] Values are mill net or ex-plant (free on board) valuations of total sales to final customers, including sales from plants' external distribution terminals. The data are ex-terminal for independently reporting terminals. Data include all varieties of portland cement and both bulk and bag shipments. Unless otherwise specified, data are presented unrounded. Unrounded or not, unit value data should be viewed as value indicators, accurate to no more than the nearest $0.50 or $1.00 per metric ton.

[3] Tonnages are those by reporting entities in the district but may include shipments into other districts. They differ from the data in table 9, which are the actual reported sales into the specific States.

[4] District is the location of the reporting entities, not necessarily the location of sales (see table 9 for sales data, by State). Specific districts include shipments by importers where district assignations were possible.

[5] Data are rounded (unit values to the nearest $0.50) because they include estimates.

[6] For 2010, data for Western Pennsylvania are included with those for Eastern Pennsylvania.

[7] Importers for which district assignations were not possible.

[8] Data may not add to totals shown because of independent rounding.

TABLE 12

MASONRY CEMENT SHIPPED IN THE UNITED STATES, BY DISTRICT [1, 2]

	2009			2010		
		Value[3]			Value[3]	
District[5]	Quantity[4] (thousand metric tons)	Total (thousands)	Average (per metric ton)	Quantity[4] (thousand metric tons)	Total (thousands)	Average (per metric ton)
Maine and New York	56	$6,265	$112.54	46	$4,712	$101.96
Pennsylvania	187	25,300 [6]	135.00 [6]	172	20,600 [6]	120.00 [6]
Illinois, Indiana, Ohio	230	33,900 [6]	147.50 [6]	213	30,800 [6]	145.00 [6]
Michigan	95	11,538	121.87	78	9,680 [6]	123.50 [6]
Iowa, Nebraska, South Dakota	15	1,921	128.09	1	98	100.88
Kansas and Missouri	51	6,353	124.50	92 [6]	12,000 [6]	129.50 [6]
Florida	192 [6]	29,100 [6]	151.50 [6]	191	25,230	131.92
Georgia, Maryland, Virginia, West Virginia	214	36,547	170.78	199	34,143	171.68
South Carolina	169	21,376	126.43	163	19,536	120.19
Alabama	242	29,735	122.90	192	24,448	127.48
Kentucky, Mississippi, Tennessee	57	8,360	146.39	55	8,033	144.87
Arkansas and Oklahoma	93	11,100 [6]	119.00 [6]	93	11,286	121.14
Texas	221	31,000	140.40	187	25,100 [6]	134.50 [6]
Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming	42	5,387	129.76	32	4,200	129.81
Alaska and Hawaii	2	620	289.54	3	796 [6]	286.50 [6]
California, Oregon, Washington	232 [6]	27,700 [6]	119.50 [6]	185	20,177	109.34
Importers[7]	6 [6]	1,220 [6]	191.50 [6]	6 [6]	1,070 [6]	174.00 [6]
Total or average[8]	2,100 [6]	287,000 [6]	136.50 [6]	1,910 [6]	252,000 [6]	132.00 [6]

[1] Shipments are those by cement companies to final customers and include imported cement and cement made from imported clinker. Sales are those by cement plants and exclude sales of masonry cement made by portland cement customers from purchased portland cement. Data exclude Puerto Rico, which did not record any masonry cement sales. Even where presented unrounded, data are thought to be accurate to no more than three significant digits.

[2] Data include true masonry, plastic, portland-lime, and stucco cements.

[3] Values are mill net or ex-plant (free on board) valuations of total sales to final customers, including sales from plants external distribution terminals. The data are ex-terminal for independently reporting terminals. Data include both bulk and bag shipments. Unless otherwise specified, data are presented unrounded. Unrounded or not, unit value data should be viewed as value indicators, accurate to no more than the nearest $0.50 or even $1.00 per metric ton.

[4] Tonnages are those by reporting entities in the district but may include shipments into other districts. They differ from the data in table 9, which are the actual reported sales into the specific States.

[5] District is the location of the reporting entities, not necessarily the location of sales (see table 9 for sales data, by State). Specific districts include importers for district assignations were possible.

[6] Data are rounded (unit values to the nearest $0.50) because they include estimates.

[7] Importers for which district assignations were not possible.

[8] Data may not add to totals shown because of independent rounding.

TABLE 13

AVERAGE MILL NET VALUE OF CEMENT SOLD IN THE UNITED STATES[1, 2]

(Dollars per metric ton)

Year	Portland cement			Masonry cement	All cement
	Gray	White[3]	Total		
2009	96.50	211.00	97.50	136.50	99.00
2010	90.00	199.00	91.00	132.00	92.00

[1] Values are average of sales to final customers, free on board the plant or independently reporting terminal. Values include any bagging charges, but exclude delivery charges to customers or to external terminals. Data exclude Puerto Rico.

[2] Data are rounded to the nearest $0.50 per metric ton because they contain estimates.

[3] Data for white cement include a component of resales showing significant price markups.

TABLE 14

PORTLAND CEMENT SHIPMENTS IN 2010, BY DISTRICT AND TYPE OF CUSTOMER[1]

(Thousand metric tons)

District[2]	Ready-mixed concrete	Concrete product manufacturers	Contractors	Building material dealers	Oil well, mining, waste stabilization	Government and other[3]	Total[4,5]
Maine and New York	1,750	256	216	213	--	64	2,459
Pennsylvania	2,260	874	390	205	24	139	3,887
Illinois	1,390	101	185	31	224	92	2,016
Indiana	1,340	214	234	38	12	71	1,907
Michigan	2,840	426	527	110	13	7	3,920
Ohio	471	66	39	11	12	--	598
Iowa, Nebraska, South Dakota	2,300	249	345	20	94	14	3,017
Kansas	1,260	141	97	51	50	1	1,596
Missouri	4,510	619	739	79	126	182	6,253
Florida	2,340	625	155	110	3	26	3,260
Georgia, Maryland, Virginia, West Virginia	2,790	767	217	96	2	103	3,978
South Carolina	1,270	251	154	82	2	134	1,894
Alabama	2,110	466	291	95	19	44	3,024
Kentucky, Mississippi, Tennessee	1,400	173	81	50	21	19	1,740
Arkansas and Oklahoma	1,340	92	583	106	122	9	2,254
Texas, northern	2,480	290	847	105	706	84	4,511
Texas, southern	3,570	443	595	233	442	21	5,300
Arizona and New Mexico	1,350	274	98	39	16	14	1,786
Colorado and Wyoming	1,440	148	256	56	187	1	2,090
Idaho, Montana, Nevada, Utah	1,350	173	155	65	203	29	1,971
Alaska and Hawaii	277	55	8	17	--	--	357
California	4,830	880	444	565	106	49	6,880
Oregon and Washington	934	144	81	55	20	10	1,244
Importers[6]	1,710	257	188	46	159	125	2,480
Total[5]	47,300	7,980	6,920	2,480	2,560	1,240	68,400
Puerto Rico	429	69	31	300	--	--	830
Grand total[5]	47,700	8,050 [7]	6,950 [8]	2,780	2,560 [9]	1,240	69,300

-- Zero.

---

[1] Includes imported cement and cement made from imported clinker. Except for district totals, data have been rounded to three significant digits, but are likely accurate to only two significant digits. District totals are likely accurate to no more than three significant digits.

[2] District is the location of the reporting entity, not the location of sales (see table 9 for sales data, by State). Specific districts include shipments by importers for which district assignations were possible.

[3] Includes shipments to miscellaneous customer types and for which customer types were not specified.

[4] District totals are unrounded except in accord with table 11.

[5] Data may not add to totals shown because of independent rounding.

[6] Shipments by importers for which district assignations were not possible.

[7] Grand total shipments to concrete product manufacturers include brick and block—2,760; precast and prestressed—2,230; pipe—889; and other or unspecified—2,170.

[8] Grand total shipments to contractors include airport—166; road paving—3,710; soil cement—1,900; and other or unspecified—1,180.

[9] Grand total shipments include oil well drilling—2,140; mining—221; and waste stabilization—201.

TABLE 15

PORTLAND CEMENT SHIPMENTS IN THE UNITED STATES, BY TYPE OF CEMENT[1, 2, 3]

(Thousand metric tons)

Type[4]	2009	2010
General use and moderate heat (Types I and II)[5, 6]	54,900 r	53,500
High early strength (Type III)	2,460	2,590
Sulfate resisting (Type V)[5]	8,610	8,630
Block	167	154
Oil well	846	1,300
White[7]	577	638
Blended:[8]		
Portland, natural pozzolans	34	48
Portland, ground granulated blast furnace slag	580	953
Portland, fly ash	357	304
Portland, other pozzolans[9]	325	263
Total blended[10]	1,300	1,570
Expansive and regulated fast setting	13	18
Miscellaneous[11]	27	30
Grand total[10]	68,900 r	68,400

[r] Revised.

[1] Includes sales of imported cement. Excludes Puerto Rico.

[2] Data are rounded to no more than three significant digits.

[3] Gray portland-type cements unless otherwise specified.

[4] Sold mostly under specifications ASTM C–150, ASTM C–595, and ASTM C–1157.

[5] Type II/V and similar sulfate-resisting cement hybrids are included within Type V.

[6] Includes ASTM C–1157 general use cements that contain no pozzolans.

[7] White or colored portland-type cements. Most are Types I or II but may include Types III and V and block cements.

[8] Cements sold under ASTM C–590 and those under ASTM C–1157 that contain pozzolans.

[9] Includes blends with cement kiln dust, silica fume, or other pozzolans, and blends containing multiple pozzolans.

[10] Data may not add to totals shown because of independent rounding.

[11] Includes low heat (Type IV), waterproof, and other portland-type cements.

TABLE 16

U.S. EXPORTS OF HYDRAULIC CEMENT AND CLINKER, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2009		2010	
	Quantity	Value[2]	Quantity	Value[2]
United States:				
Angola	2	323	1	1,153
Anguilla	4	255	(3)	3
Aruba	2	336	1	157
Australia	(3)	106	1	404
Bahamas, The	48	5,628	99	9,063
Belize	36	1,513	7	693
Brazil	(3)	39	3	213
Canada	674	79,836	807	113,598
Cayman Islands	(3)	95	1	103
China	(3)	133	2	955
Colombia	1	680	2	715
Costa Rica	(3)	19	3	135
Dominican Republic	2	219	1	483
Greece	15	729	14	637
Haiti	1	62	13	1,056
Hong Kong	1	326	1	402
India	(3)	97	2	264
Ireland	4	225	6	367
Israel	(3)	92	1	262
Jamaica	26	2,737	66	6,556
Japan	1	225	11	2,526
Madagascar	--	--	1	60
Mexico	23	5,915	39	8,914
Netherlands Antilles	1	196	2	366
Pakistan	1	43	(3)	82
Panama	28	3,794	67	8,051
Peru	1	198	1	364
Russia	1	47	(3)	90
St. Christopher and Nevis	2	102	(3)	57
Suriname	(3)	39	1	108
Sweden	1	77	(3)	81
Taiwan	(3)	149	1	3,099
Trinidad and Tobago	(3)	98	1	346
Turks and Caicos Islands	(3)	55	8	759
United Kingdom	(3)	75	9	1,614
Other	6 r	2,868 r	7	4,629
Total[4]	884	107,330	1,178	168,308
Puerto Rico:				
British Virgin Islands	15	1,807	4	664
Netherlands Antilles	(3)	5	3	231
Turks and Caicos Islands	1	152	--	--
Other	(3)	30	(3)	3
Total[4]	16	1,994	7	898
Grand total[4]	900	109,323	1,185	169,206

See footnotes at end of table.

TABLE 16—Continued

U.S. EXPORTS OF HYDRAULIC CEMENT AND CLINKER, BY COUNTRY [1]

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[r] Revised. -- Zero.

[1] Includes portland and masonry cements.

[2] Free alongside ship value. The value of exports at the U.S. seaport or border point of export is based on the transaction price, including inland freight, insurance, and other charges incurred in placing the merchandise alongside the carrier. The value excludes the cost of loading.

[3] Less than ½ unit.

[4] Data may not add to totals shown because of independent rounding.

Source: U.S. Census Bureau.

TABLE 17
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2009			2010		
		Value			Value	
Country	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
United States:						
Algeria	14	1,576	2,123	9	811	1,135
Canada	3,426	272,829	291,298	3,410	265,248	283,314
China	608	35,251	50,161	655	34,975	51,111
Colombia	654	39,799	56,216	315	19,652	27,367
Croatia	15	5,687	6,890	24	9,459	11,346
Denmark	69	9,924	12,302	54	9,653	13,262
Dominican Republic	4	307	381	(4)	10	11
Egypt	55	6,345	7,965	56	5,160	7,097
France	65	20,373	21,607	91	31,318	32,960
Greece	186	10,705	12,429	191	9,173	11,918
India	1	151	209	1	68	102
Japan	1	523	654	28	2,348	2,552
Korea, Republic of	855	34,694	56,700	1,018	39,214	61,801
Mexico	366	35,342	39,132	370	36,703	40,138
Netherlands	2	1,925	2,539	3	3,363	3,735
Sweden	74	3,821	7,074	83	3,524	6,804
Taiwan	254	11,332	16,677	265	11,242	17,825
Thailand	21	2,594	3,801	16	2,159	3,382
Trinidad and Tobago	--	--	--	8	544	551
Turkey	95	7,858	12,220	21	1,881	2,637
United Kingdom	1	153	281	1	171	290
Venezuela	--	--	--	8	2,648	3,405
Other	1 r	403 r	488 r	1	436	544
Total[5]	6,767	501,592	601,148	6,626	489,762	583,288
Puerto Rico:						
Colombia	5	674	862	7	898	1,172
Korea, Republic of	27	1,350	2,322	27	1,350	2,322
Mexico	14	1,641	2,216	12	1,393	1,970
Spain	81	5,694	7,064	109	7,206	9,166
Other	(4)	174 r	181 r	(4)	80	92
Total[5]	127	9,532	12,645	155	10,927	14,721
Grand total[5]	6,894	511,125	613,793	6,781	500,689	598,009

r Revised. -- Zero.

[1] Includes portland, masonry, and other hydraulic cements.

[2] Customs value. The price actually paid or payable for merchandise when sold for exportation to the United States, excluding insurance, and other charges incurred in bringing the merchandise to the United States.

[3] Cost, insurance, and freight. The import value represents the customs value plus insurance, freight, and other delivery charges to the first port of entry.

[4] Less than ½ unit.

[5] Data may not add to totals shown because of independent rounding.

Source: U.S. Census Bureau.

TABLE 18
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2009			2010		
		Value			Value	
Customs district and country	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
United States:						
Anchorage, AK:						
Canada	9	745	2,267	5	298	1,017
China	15	1,036	1,561	12	842	842
Korea, Republic of	72	3,165	5,658	95	3,968	7,676
Taiwan	16	1,047	1,066	--	--	--
Total[4]	112	5,994	10,552	112	5,108	9,536
Baltimore, MD:						
China	--	--	--	1	18	22
Other	(5)	62	70	(5)	39	43
Total[4]	(5)	62	70	1	57	64
Boston, MA:						
Canada	77	4,196	6,824	23	1,010	1,693
Other	--	--	--	(5)	36	37
Total[4]	77	4,196	6,824	23	1,046	1,731
Buffalo, NY:						
Canada	574	48,103	52,028	590	49,366	52,718
Other	(5)	13	13	(5)	24	24
Total[4]	574	48,116	52,041	590	49,390	52,742
Charleston, SC, Other	(5)	59	70	(5)	71	82
Chicago, IL, Other	(5)	218	280	1	744	865
Cleveland, OH:						
Canada	493	34,399	36,894	554	40,960	44,235
Other	(5)	159	183	1	800	950
Total[4]	494	34,558	37,077	555	41,759	45,185
Columbia-Snake, ID, OR, WA:						
Canada	55	4,256	4,503	56	3,802	4,007
China	237	13,016	19,757	277	12,893	20,154
Other	--	--	--	(5)	8	8
Total[4]	292	17,272	24,259	332	16,703	24,169
Dallas-Fort Worth, TX, Netherlands	(5)	34	95	--	--	--
Detroit, MI:						
Canada	841	66,897	68,458	939	72,812	78,669
Other	(5)	101	142	(5)	175	192
Total[4]	841	66,998	68,600	939	72,988	78,862
Duluth, MN, France	--	--	--	(5)	3	3
El Paso, TX:						
Canada	--	--	--	(5)	33	36
Mexico	275	23,449	25,875	266	23,407	25,705
Total[4]	275	23,449	25,875	266	23,440	25,741
Great Falls, MT, Other	(5)	189	227	(5)	79	109

See footnotes at end of table.

TABLE 18—Continued
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

Customs district and country	2009			2010		
		Value			Value	
	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
Honolulu, HI:						
China	(5)	14	47	(5)	15	24
Korea, Republic of	84	3,569	7,329	165	7,278	10,421
Taiwan	188	8,281	12,233	112	4,928	7,537
Thailand	3	188	552	--	--	--
Total[4]	276	12,052	20,160	277	12,221	17,983
Houston-Galveston, TX:						
Algeria	6	728	1,022	--	--	--
China	2	186	274	4	390	402
Colombia	235	14,822	20,624	9	1,239	1,514
Egypt	28	3,230	3,988	28	2,591	3,543
Korea, Republic of	472	19,219	30,821	571	21,418	34,614
Taiwan	49	1,968	3,198	--	--	--
Other	(5)	124	146	1	404	484
Total[4]	793	40,278	60,074	612	26,041	40,558
Laredo, TX, Mexico	85	11,467	12,646	88	11,887	12,441
Los Angeles, CA:						
China	21	2,408	2,876	26	2,926	3,149
Egypt	1	68	72	3	255	349
Thailand	12	1,629	2,202	10	1,322	2,064
Other	1	404	592	1	203	303
Total[4]	35	4,508	5,741	39	4,706	5,864
Miami, FL:						
Algeria	7	848	1,101	9	811	1,135
Colombia	6	790	997	5	735	877
Egypt	19	2,197	2,807	15	1,402	1,954
Mexico	5	410	590	15	1,372	1,915
Sweden	73	3,270	6,455	82	3,057	6,230
Turkey	74	6,618	9,585	21	1,871	2,628
Other	(5)	41	73	(5)	27	30
Total[4]	185	14,174	21,609	147	9,276	14,769
Minneapolis, MN:						
Canada	113	12,105	12,117	118	13,923	13,937
Other	(5)	31	31	(5)	5	6
Total[4]	113	12,136	12,148	118	13,929	13,943
Mobile, AL, Mexico	(5)	7	12	--	--	--
New Orleans, LA:						
China	5	1,062	1,269	9	1,990	2,165
Croatia	15	5,410	6,542	22	8,891	10,567
Korea, Republic of	34	1,273	1,961	47	1,533	3,056
Taiwan	1	36	180	--	--	--
Turkey	21	1,240	2,634	--	--	--
Other	--	--	--	(5)	25	28
Total[4]	75	9,021	12,586	78	12,438	15,816

See footnotes at end of table.

TABLE 18—Continued
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2009			2010		
		Value			Value	
Customs district and country	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
New York City, NY:						
Denmark	24	2,804	3,655	21	2,137	2,758
France	3	107	110	(5)	39	45
Greece	186	10,705	12,429	191	9,173	11,918
Other	1	260	355	1	299	378
Total[4]	214	13,876	16,550	213	11,648	15,099
Nogales, AZ, Mexico	(5)	9	10	--	--	--
Norfolk, VA:						
Canada	53	5,003	5,373	13	1,366	1,454
Egypt	3	389	482	1	122	177
France	63	20,222	21,447	91	31,175	32,792
Sweden	1	551	619	1	342	421
Other	(5)	34	39	8	2,663	3,420
Total[4]	120	26,198	27,961	113	35,667	38,264
Ogdensburg, NY:						
Canada	248	23,489	23,989	174	14,839	15,398
Other	(5)	5	5	(5)	13	14
Total[4]	248	23,494	23,994	174	14,852	15,412
Pembina, ND, Canada	162	12,370	12,455	167	10,701	10,787
Philadelphia, PA:						
Korea, Republic of	139	4,988	7,063	139	5,018	6,033
Netherlands	1	814	937	1	1,261	1,400
Other	(5)	111	153	(5)	59	105
Total[4]	140	5,913	8,153	141	6,337	7,538
Portland, ME:						
Canada	37	4,469	4,954	26	2,372	2,676
Japan[6]	--	--	--	27[6]	1,332	1,332
Total[4]	37	4,469	4,954	53	3,705	4,009
Providence, RI, Canada	62	4,069	6,273	40	2,290	3,404
San Francisco, CA:						
China	211	10,114	13,216	42	2,555	3,168
Egypt	1	108	173	2	182	265
India	1	127	184	1	68	102
Taiwan	--	--	--	153	6,314	10,288
Thailand	6	777	1,047	6	799	1,260
Total[4]	219	11,126	14,620	203	9,919	15,083
Savannah, GA:						
Colombia	221	12,861	18,609	149	8,447	12,201
Egypt	3	354	443	7	608	809
Other	(5)	256	398	(5)	255	282
Total[4]	224	13,471	19,450	156	9,310	13,292
Seattle, WA:						
Canada	611	42,802	44,572	630	43,279	44,627
China	117	7,158	10,833	285	13,170	20,940
Japan	1	398	519	1	550	703
Korea, Republic of	54	2,480	3,869	--	--	--
Other	(5)	40	61	(5)	116	139
Total[4]	783	52,879	59,853	916	57,115	66,410

See footnotes at end of table.

TABLE 18—Continued
U.S. IMPORTS FOR CONSUMPTION OF HYDRAULIC CEMENT AND CLINKER, BY CUSTOMS DISTRICT AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2009			2010		
		Value			Value	
Customs district and country	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	
St. Albans, VT:						
Canada	89	9,904	10,571	75	8,181	8,6
Other	(5)	4	4	(5)	7	
Total[4]	89	9,907	10,575	75	8,188	8,6
St. Louis, MO:						
Croatia	--	--	--	1	371	5
Other	(5)	340	459	(5)	501	5
Total[4]	(5)	340	459	1	872	1,0
Colombia	58	3,225	4,557	22	1,640	2,0
Denmark	45	7,117	8,644	34	7,510	10,4
Total[4]	103	10,342	13,201	56	9,150	12,5
U.S. Virgin Islands:						
Colombia	--	--	--	13	291	3
Dominican Republic	4	307	381	--	--	
Trinidad and Tobago	--	--	--	8	544	5
Total[4]	4	307	381	21	835	8
Wilmington, NC:						
Colombia	134	8,033	11,313	117	7,270	10,34
Netherlands	--	--	--	(5)	19	2
Total[4]	134	8,033	11,313	117	7,289	10,36
U.S. total[4]	6,767	501,592	601,148	6,626 [6]	489,762	
Puerto Rico (San Juan):						
Colombia	5	674	862	7	898	1,17
Korea, Republic of	27	1,350	2,322	27	1,350	2,32
Mexico	14	1,641	2,216	12	1,393	1,97
Spain	81	5,694	7,064	109	7,206	9,16
Other	(5)	174	181	(5)	80	9
Total[4]	127	9,532	12,645	155	10,927	14,72
Grand total[4]	6,894	511,125	613,793	6,781 [6]	500,689	

-- Zero.

[1] Includes all varieties of hydraulic cement and clicker.

[2] Customs value. The price actually paid or payable for merchandise when sold for exportation to the United States, excluding U.S. im duties, freight,insurance, and other charges incurred in bringing the merchandise to the United States.

[3] Cost, insurance, and freight. The import value represents the customs value plus insurance, freight, and other delivery charges to the first port of entry.

[4] Data may not add to totals shown because of independent rounding.

[5] Less than ½ unit.

[6] Material (27,070 metric tons in August 2010) from Japan into Portland, ME, is granulated blast furnace slag, not hydraulic cement as recorded in error by the importer.

Source: U.S. Census Bureau.

TABLE 19
U.S. IMPORTS FOR CONSUMPTION OF GRAY PORTLAND CEMENT, BY COUNTRY

(Thousand metric tons and thousand dollars)

	2009			2010		
		Value			Value	
Country	Quantity	Customs[1]	C.i.f.[2]	Quantity	Customs[1]	C.i.f.[2]
United States:						
Canada	2,642	205,197	222,340	2,626	199,772	216,660
China	573	30,463	44,369	606	28,532	44,096
Colombia	636	37,333	52,800	274	15,638	22,335
Dominican Republic	4	307	381	(3)	10	11
France	3	107	110	--	--	--
Greece	186	10,705	12,429	191	9,173	11,918
Korea, Republic of	854	34,641	56,563	1,017	39,169	61,707
Mexico	185	11,770	13,305	184	12,311	13,833
Sweden	73	3,270	6,455	82	3,057	6,230
Taiwan	254	11,332	16,677	265	11,242	17,825
Thailand	3	188	552	(3)	11	13
Other	(3)	216[r]	324[r]	9	750	820
Total[4, 5]	5,414	345,529	426,307	5,254	319,665	395,448
Puerto Rico:						
Dominican Republic	--	--	--	(3)	2	2
Korea, Republic of	27	1,350	2,322	27	1,350	2,322
Spain	81	5,694	7,064	109	7,186	9,146
Total[4, 5]	108	7,044	9,386	136	8,539	11,470
Grand total[4, 5]	5,521	352,572	435,693	5,390	328,204	406,918

[r] Revised. -- Zero.

[1] The price actually paid or payable for merchandise when sold for exportation to the United States, excluding U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise to the United States.

[2] Cost, insurance, and freight. The import value represents the customs value plus insurance, freight, and other delivery charges to the first port of entry.

[3] Less than ½ unit.

[4] Data may not add to totals shown because of independent rounding.

[5] Total imports do not include gray portland cement that was misregistered by importers under the white cement tariff code; these quantities are included in table 20.

Source: U.S. Census Bureau.

TABLE 20
U.S. IMPORTS FOR CONSUMPTION OF WHITE CEMENT, BY COUNTRY

(Thousand metric tons and thousand dollars)

Country	2009			2010		
		Value			Value	
	Quantity	Customs[1]	C.i.f.[2, 3]	Quantity	Customs[1]	C.i.f.[2, 3]
United States:						
Algeria	14	1,576	2,123	9	811	1,135
Canada	251	33,932	34,681	252	34,814	35,573
China	29	3,396	4,125	38	4,105	4,407
Colombia	18	2,466	3,415	20	2,792	3,278
Denmark	69	9,921	12,300	54	9,647	13,255
Egypt	53	6,028	7,628	56	5,160	7,097
India	1	130	178	1	68	102
Korea, Republic of	2	53	137	(4)	45	94
Mexico	113	15,822	17,357	121	16,560	17,832
Thailand	18	2,406	3,249	16	2,149	3,369
Turkey	95	7,858	12,220	21	1,871	2,628
United Kingdom	1	99	219	(4)	121	235
Other	(4)	7	7	(4)	30	33
Total[5]	664[6]	83,693	97,638	588	78,173	89,038
Puerto Rico:						
Colombia	5	674	862	7	898	1,172
Mexico	14	1,641	2,216	12	1,393	1,970
Other	--	--	--	(4)	51	54
Total[5]	19	2,315	3,078	19	2,342	3,195
Grand total[5]	683[6]	86,008	100,715	607	80,515	92,233

-- Zero.

[1] Customs value. The price actually paid or payable for merchandise when sold for exportation to the United States, excluding U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise to the United States.

[2] Cost, insurance, and freight. The import value represents the customs value plus insurance, freight, and other delivery charges to the first port of entry.

[3] Values of less than $90.00 (c.i.f.) per metric ton likely indicate the mistaken total or partial inclusion of data for gray portland or similar cement or clinker. This error happens when the importer records the wrong tariff number with the U.S. Customs Service. Values that exceed $200 per ton likely indicate misidentified specialty cement, not white cement.

[4] Less than ½ unit.

[5] Data may not add to totals shown because of independent rounding.

[6] Total imports of white cement include substantial quantities of gray cement that were misregistered by importers under the white cement tariff code.

Source: U.S. Census Bureau.

TABLE 21
U.S. IMPORTS FOR CONSUMPTION OF CLINKER, BY COUNTRY [1]

(Thousand metric tons and thousand dollars)

	2009			2010		
		Value			Value	
Country	Quantity	Customs[2]	C.i.f.[3]	Quantity	Customs[2]	C.i.f.[3]
Canada	489	30,192	30,459	501	27,512	27,799
China	3	709	855	1	175	231
Colombia	--	--	--	21	1,222	1,754
Egypt	3	318	337	--	--	--
France	62	19,571	20,732	89	29,595	31,090
United Kingdom	--	--	--	(4)	7	7
Total[5]	556	50,789	52,383	613	58,511	60,882

-- Zero.

[1] For all types of hydraulic cement.

[2] Customs value. The price actually paid or payable for merchandise when sold for exportation to the United States, excluding U.S. import duties, freight, insurance, and other charges incurred in bringing in the merchandise to the United States.

[3] Cost, insurance, and freight. The import value represents the customs value plus insurance, freight, and other delivery charges to the first port of entry.

[4] Less than ½ unit.

[5] Data may not add to totals shown because of independent rounding.

Source: U.S. Census Bureau.

TABLE 22

HYDRAULIC CEMENT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2006	2007	2008	2009	2010[e]
Afghanistan	50	50 [e]	37 [r]	32 [r]	36 [3]
Albania	525	889	918 [r]	1,108 [r]	1,300
Algeria	14,702	15,886	17,398	19,100 [r]	20,000
Angola[e]	1,373 [3]	1,400	1,780	1,800	1,500
Argentina	8,929	9,602	9,703	10,000 [e]	10,000
Armenia	625	722	770	467 [r]	488 [3]
Australia[e]	9,000	9,200 [r]	9,400 [r]	9,200 [r]	9,000
Austria	4,852	5,203	5,309	4,646 [r]	4,254 [3]
Azerbaijan	1,622	1,693 [r]	1,595	1,286 [r]	1,279 [3]
Bahrain	400	400	438	700 [r, e]	1,200
Bangladesh[e]	5,100	5,100	5,000	5,000	5,000
Barbados	338	294	316 [r]	301 [r]	300
Belarus	3,495	3,821 [r]	4,219	4,350	4,531 [3]
Belgium	8,192	9,571 [r]	6,225 [r]	9,403 [r]	8,722 [3]
Benin[e]	1,489 [3]	1,550	1,500	1,500	1,500
Bhutan[e]	180	180	180	180	180
Bolivia	1,636	1,739	1,985	2,292	2,414 [3]
Bosnia and Herzegovina	1,226	1,283	1,406	1,074	949 [3]
Brazil	41,895	46,551	51,970	51,748	59,118 [3]
Brunei[e]	240	200	240	220	220
Bulgaria	4,093	4,413	4,903	2,662	3,000
Burkina Faso[e]	30	30	30	30	30
Burma[4]	570	608	676	670	534 [3]
Cambodia	--	87	772	774	775
Cameroon[e]	1,000	1,150 [3]	1,000	1,000	1,000
Canada	14,336	15,078	13,672	10,985	12,431 [3]
Chile	4,112	4,440	4,622	3,876	3,871 [3]
China	1,236,770	1,361,170	1,400,000	1,644,000 [r]	1,880,000 [p, 3]
Colombia[5]	10,038	11,068	10,456	9,232 [r]	9,488 [3]
Congo (Brazzaville)[e]	100	100	105 [r]	110 [r]	100
Congo (Kinshasa)	519	530	411	444	530
Costa Rica	1,400 [r]	2,300	2,500	1,498 [r]	1,276 [3]
Côte d'Ivoire	360 [r]	469 [r]	360 [r]	283 [r]	280
Croatia	3,598	3,587	3,637	2,838 [r]	2,664 [3]
Cuba	1,705	1,805	1,707	1,626 [r]	1,600
Cyprus	1,786	1,873	1,870 [e]	1,481 [r]	1,329 [3]
Czech Republic	4,239	4,899	4,710	3,637	3,345 [3]
Denmark	2,937 [r]	2,871 [r]	2,539 [r]	1,578 [r]	2,000
Dominican Republic[e]	3,777 [3]	4,100	4,000	3,000	3,000
Ecuador	4,110	4,420	5,493	5,000 [e]	5,000
Egypt	36,100 [r]	38,469 [r]	39,844 [r]	46,500	48,000
El Salvador	1,311	1,300 [e]	1,300 [e]	1,212 [r]	1,200
Eritrea[e]	45	45	45	45	45
Estonia	849	937	808	326	375
Ethiopia	1,731	1,626	1,834	2,300 [e]	2,700
Fiji[e]	143	145	143	110	110
Finland	1,685	1,743	1,745	1,052 [r]	1,050
France	22,540	22,300 [e]	21,700	18,300	18,300
French Guiana[e]	62 [r]	62 [r]	62	62	62
Gabon[e]	260	229 [3]	230	230	230

See footnotes at end of table.

TABLE 22—Continued
HYDRAULIC CEMENT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2006	2007	2008	2009	2010[e]
Georgia[e]	450	450	450	870 [r, 3]	857 [3]
Germany	33,630	33,382	33,581	30,441	29,894 [3]
Ghana[e]	1,800	1,800	1,800	1,800	1,800
Greece	15,674	16,667	16,500 [e]	16,000 [e]	15,000
Guadeloupe[e]	230	230	230	230	230
Guatemala[e]	2,400 [r]	2,500	2,500	1,500	1,500
Haiti[e]	290 [r]	290 [r]	290 [r]	290 [r]	290
Honduras	1,668 [r]	1,776 [r]	1,784 [r]	1,800 [e]	1,800
Hong Kong[e]	1,010	1,000	1,000	1,000	1,000
Hungary	3,724	3,552	3,544	3,200 [e]	3,200
Iceland[e]	141 [3]	140 [r]	138 [r]	138 [r]	138
India[e]	160,000	170,000	185,000	205,000	210,000
Indonesia[e]	35,000	36,000	36,000	22,195 [r, 3]	22,000
Iran[e]	35,300	41,000	44,400 [3]	50,000	50,000
Iraq[e]	3,500	4,500	6,453 [3]	8,500	10,000
Ireland[e]	4,981 [3]	4,700 [r]	3,900 [r]	2,600 [r]	2,600
Israel	5,089	5,000 [e]	4,819	4,759	5,139 [3]
Italy	47,814	47,542	43,030	36,317	36,300
Jamaica	761	592	725	737 [r]	723 [3]
Japan	69,942	67,685	62,810	54,800	51,526 [3]
Jordan	3,967	4,138 [r]	4,284 [r]	3,799 [r]	4,000
Kazakhstan	4,880	5,699	5,837 [r]	5,694 [r]	6,686 [3]
Kenya	2,174	2,546	2,829	3,320	3,730
Korea, North[e]	6,160	6,130	6,415 [3]	6,400	6,400
Korea, Republic of	53,971	52,182	51,653	50,127	47,236 [3]
Kosovo[6]	450 [e]	470	590	600 [e]	600
Kuwait[e]	2,200 [3]	2,200	2,600 [r]	2,000	2,000
Kyrgyzstan	1,060	1,230	1,218	579 [r]	600
Laos[e]	400	400	400	400	400
Latvia[e]	280	300	310	650 [r]	1,100
Lebanon	3,348 [r]	3,945 [r]	4,250 [r]	4,900 [r]	5,227 [3]
Liberia	155	157	94	71 [r]	67 [3]
Libya	5,300 [e]	5,206	5,509	6,500	6,000
Lithuania	1,065	1,105 [r]	1,076 [r]	583 [r]	834 [3]
Luxembourg	901 [r]	1,081 [r]	1,091 [r]	1,000 [r]	1,078 [3]
Macedonia	924	945	916	909	910
Madagascar[e]	150	270 [3]	270	240	270
Malawi	188	185	240 [e]	240 [e]	240
Malaysia	18,400 [e]	19,480	19,629 [r]	19,457 [r]	19,500
Martinique[e]	220	220	220	220	220
Mauritania	374	410	322 [r]	340 [r]	350
Mexico	40,362	38,757 [r]	37,139 [r]	35,160	34,502 [3]
Moldova[e]	837 [3]	800	750	700	700
Mongolia	141	180	269	235 [r]	323 [3]
Morocco	11,352 [r]	12,792 [r]	14,047 [r]	14,519 [r]	14,000
Mozambique[7]	605 [r]	665 [r]	744 [r]	777 [r]	884 [3]
Nepal[e, 4]	295	300	295	295 [r]	295
Netherlands[e]	2,790 [3]	2,700	2,700	2,700	2,700
New Caledonia	119 [r]	122 [r]	137 [r]	138 [r]	160 [3]

See footnotes at end of table.

TABLE 22—Continued

HYDRAULIC CEMENT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2006	2007	2008	2009	2010[e]
New Zealand[e]	1,120 [3]	1,100	1,100	1,100	1,200
Nicaragua[e]	530	530	530	530	530
Niger[e]	62 [r]	42 [r]	40 [r]	40	40
Nigeria	3,300	4,700	5,000	5,000 [r]	5,400
Norway[e]	1,695 [3]	1,700	1,700	1,650	1,650
Oman	3,611	3,880	3,991	4,000 [e]	4,200
Pakistan	20,652	25,745 [r]	26,000 [r, e]	28,000 [r, e]	30,000
Panama	1,050 [e]	1,050 [e]	1,843 [r]	1,679 [r]	1,700
Paraguay[e]	600	600	600	600	600
Peru	5,782	6,231	6,922	6,862	6,865 [p, 3]
Philippines[8]	12,033	13,048	13,369	14,865	15,900 [3]
Poland	14,688	17,120	17,207	15,537	15,521 [3]
Portugal	8,340	12,631	12,650	12,700	12,750 [3]
Qatar	1,568	2,400 [r, e]	3,800 [r, e]	4,095 [r]	3,780 [3]
Réunion[e]	400	400	400	375	375
Romania	8,253	10,060 [r]	10,660 [r]	7,902 [r]	7,008 [3]
Russia	54,731 [r]	59,939 [r]	53,548 [r]	44,266 [r]	50,400
Rwanda	103	103	103	92 [r]	100
Saudi Arabia	27,056	30,369	31,823	36,500 [r]	42,300 [3]
Senegal	2,884	3,152	3,084	3,327 [r]	3,000
Serbia[9]	2,565	2,677	2,843	2,232	2,300
Sierra Leone	234	236	254	236 [r]	230
Slovakia	3,593	3,718	4,157	3,011	2,888 [3]
Slovenia[e]	1,269 [3]	1,300	1,300	1,000	1,000
South Africa, sales	12,658	13,651	13,473 [r]	11,784 [r]	13,000
Spain, including Canary Islands	54,033	54,720	42,088	29,505	23,473 [3]
Sri Lanka[e]	1,600	1,700	1,800	1,900	2,000
Sudan	202	326	247 [r]	622 [r]	962 [3]
Suriname[e]	65	65	65	65	65
Sweden	2,952	2,950	2,900 [e]	2,950 [e]	2,900
Switzerland[e]	4,040 [3]	4,000	4,000	4,000	4,000
Syria	4,804	5,104	5,336	5,605	6,000 [3]
Taiwan	19,294	18,957	17,330	15,918	16,301 [3]
Tajikistan	282	313	190	195 [r]	288 [3]
Tanzania	1,370	1,630	1,756	1,941 [r]	2,000
Thailand	39,408	35,668	31,651	33,562 [r]	36,496 [3]
Togo[e]	800	800	800	800	800
Trinidad and Tobago	883	902 [r]	958	870 [r]	800
Tunisia	6,932	7,052	7,559	7,511 [r]	7,500
Turkey	47,499	49,553	54,027	53,973	62,737 [3]
Turkmenistan	921 [r]	941 [r]	1,026 [r]	1,100 [r]	1,100
Uganda[e]	630	650	650	650	650
Ukraine	13,732	15,000	14,918	9,496	9,457 [3]
United Arab Emirates	13,000 [r, e]	16,000 [r, e]	21,885	18,997	18,000
United Kingdom	11,471 [r]	11,887	10,071	7,623 [r]	7,600
United States, including Puerto Rico[10]	99,712	96,850	87,610	64,843 [r]	67,176 [3]
Uruguay[e]	620	620	620	620	620
Uzbekistan[e]	5,700	6,500 [3]	6,600	6,850 [r]	6,872 [3]

See footnotes at end of table.

TABLE 22—Continued

HYDRAULIC CEMENT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2006	2007	2008	2009	2010[e]
Venezuela[e]	11,000 [r]	11,000 [r]	11,000 [r]	11,000 [r]	11,000
Vietnam	32,690	37,102	40,009	47,900	50,000
Yemen	1,470	1,728	2,111 [r]	2,118 [r]	3,000
Zambia[e]	550 [r]	540 [r]	560 [r]	880 [r]	1,000
Zimbabwe[e]	700	400	400	700 [r]	700
Total[e]	2,620,000 [r]	2,810,000	2,850,000	3,030,000 [r]	3,310,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown. Even where presented unrounded, reported data are thought to be accurate to no more than three significant digits. Data are from a variety of sources, including the European Cement Association.

[2] Table includes data available through July 23, 2011. Data may include clinker exports for some countries.

[3] Reported figure.

[4] Data are for fiscal year ending March 31 of the following year.

[5] Data for 2006–08 are for gray cement only; white cement output was likely to have been an additional 50,000 to 100,000 tons per year.

[6] Not included in Serbia data.

[7] Cement sales from Cimentos de Moçambique SARL (Sociedade Anónima de Responsabilidade Limitada) only.

[8] Philippines reports cement production, in bags: 2006—300,822,821; 2007—334,228,355; 2008—378,214,634; 2009—371,628,730; and 2010—375,000,000 (estimated).

[9] Excludes Kosovo data.

[10] Portland and masonry cements only. Includes a small (less than 0.3% per year) component of double-counting where portland cement (not clinker) is consumed to make masonary cement; the precise amount of double-counting can not be determined because of the involvement of portland cement stockpiles.

CHROMIUM

By John F. Papp

Domestic survey data and tables were prepared by Lisa Mersdorf, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2010, the U.S. chromium supply (measured in contained chromium) was 144,000 metric tons (t) from recycled stainless steel scrap, 499,000 t from imports, and 136,000 t from Government and industry stocks. Supply distribution was 274,000 t to exports, 122,000 t to Government and industry stocks, and 383,000 t to apparent consumption. Chromium apparent consumption increased by 140% compared with that of 2009.

Legislation and Government Programs

The Defense Logistics Agency, DLA Strategic Materials (DLA) disposed of chromium materials under its fiscal year 2010 (October 1, 2009, through September 30, 2010) Annual Materials Plan (AMP) and announced the fiscal year 2011 plan. The DLA's fiscal year 2011 AMP set maximum disposal goals for chromium materials at 90,700 t of chromium ferroalloys and 454 t of chromium metal (Defense Logistics Agency, DLA Strategic Materials, 2011).

Production

Industrial Minerals Corp. Ltd. (Australia) (IMC) continued construction on the Oregon Heavy Minerals Project (OHMP) to recover chromite from paleo-beach placer (heavy-mineral sand) deposits in Coos County, OR. IMC reported proved and probable ore reserves of 8.26 million metric tons (Mt) at an average grade of 7.41% chromic oxide (Cr_2O_3). IMC planned to mine ore and reclaim dry tailings concurrently in the same pit. Run-of-mine ore would be stockpiled at the mine site before being transported about 30 kilometers to the mineral separation plant. Dry tailings would be returned for mine reclamation. At the mineral separation plant, ore sand would first pass through wet spirals that separate constituent minerals by density. The ore, which consists of the heavy minerals chromite, garnet, high-iron ilmenite, and zircon, would then be separated from gangue material via a dry process comprising electrostatic, magnetic, and density separators. IMC planned to start commercial production in 2011 under the name Oregon Resources Corp. Oregon Resources planned to produce 63,000 metric tons per year (t/yr) of foundry-grade chromite, which differs from traditional foundry-grade chromite sand because of its origin—beach sands (Drew and others, 2010, p. 29–39; Industrial Minerals Corp. Ltd., 2011, p. 12–24).

Elementis Chromium [a subsidiary of Elementis plc (United Kingdom)] produced sodium dichromate from chromite ore at Castle Haynes, NC.

The stainless steel industry is the leading consumer of chromium materials. AK Steel Corp., Allegheny Technologies Inc., and North American Steel Co. were the leading U.S. stainless steel producers in 2010. The U.S. stainless steel industry produced more than 2 million metric tons per year (Mt/yr) of stainless steel and imports and exports stainless steel mill products and scrap, which account for a significant amount of chromium in U.S. trade.

Consumption

Domestic data for chromium materials were developed by the U.S. Geological Survey (USGS) by means of the monthly "Chromite Ores and Chromium Products" and "Consolidated Consumers" consumer surveys. Stainless and heat-resisting steel producers are the leading chromium consumers, and high-carbon ferrochromium is the leading chromium-containing material consumed.

Roberts (2010, p. 40–48) observed that chromite sand has traditionally been commonly used as a facing sand on manganese steel castings or for large castings or thick sections; however, it is also used as a molding sand and in a wide range of ferrous and nonferrous castings.

The U.S. Department of Energy (2011, p. 30) reported that iron-chromium batteries may play an essential role in clean energy generation and distribution by storing energy generated in excess of immediate demand for later use.

Technology

Chromite ore is a combination of chromite minerals and gangue minerals that are separated through the beneficiation process after mining. Chromite mineral is the chromium-rich component of a complex family of spinel group oxide minerals comprising aluminum, chromium, magnesium, and (or) iron in solid solution. The chromium-rich components are magnesium chromite ($MgCr_2O_4$) and iron chromite ($FeCr_2O_4$). Gangue minerals comprise one or more silicate minerals. Gangue minerals affect the performance of chromite products, because beneficiation does not completely separate them from chromite ore. Metamorphosis of ore can result in the Cr_2O_3 reporting to the gangue minerals stream (tailings) during beneficiation (Greico, 2010).

Mineral beneficiation of chromite ore from South Africa and Zimbabwe is the exploitation of physical properties, such as density and chemical, magnetic, and surface characteristics, to produce concentrates. Current chromite ore beneficiation practice is to separate chromite ore from gangue minerals via dense media separation or gravity separation, which take advantage of the higher density of chromite minerals [4.3 to 4.5 grams per cubic centimeter (g/cm^3)] compared to that of silicates (the gangue minerals) (2.6 to 4.0 g/cm^3). New methods will be required to process lower grade or mineralogically more complex chromite ore deposits. Future beneficiation may incorporate preconcentration, sensor-based sorting, or higher density cut points of dense media separation (McKenzie, 2010).

Cookson (2010) compared ferrochromium process technologies, capital equipment costs, power requirements, reductant and ore consumption, and production costs for the ChromeRed, ChromeRed plus DCF SAF, direct current furnace (DCF), Outotec, and submerged arc furnace (SAF) processes for a greenfield ferrochromium plant to be constructed in 2 years, which would produce 252,000 metric tons per year (t/yr), and consume South African MG1 chromite ore comprised of 70% concentrate, 20% lumpy, and 10% chip. Such a plant would cost $450 million to $500 million to construct, consume 2,070 to 3,080 kilowatthours (kWh) of electricity per ton of ferrochromium, require 1.95 to 2.06 t of chromite ore per ton of ferrochromium, and cost 46.36 to 59.40 cents per pound of chromium produced. DCF SAF and ChromeRed had the lowest capital cost at $454 million. ChromeRed had the lowest power consumption at 2,250 kilowatthours per metric ton and the lowest production cost at 46.36 cents per pound of contained chromium.

Prices

Market forces and the U.S. dollar-South African rand exchange rate affected the price of ferrochromium (Davidson, 2010). Exchange rate change accounted for about 31% of the ferrochromium price increase in 2010 from that of 2009 (Pacific Exchange Rate Service, 2011).

World Industry Structure

The geographic distribution of mineral production has changed during the past 150 years. Europe, along with the United States, accounted for nearly all of mineral production in the mid-19th century, but together now account for less than one-fifth of world mineral production. The world share of mineral production from the United States and Europe had been decreasing while the share from Australia, Canada, China, Commonwealth of Independent States (CIS), and a number of developing countries has been increasing. While minerals and metals are not being mined to extinction, mineral scarcity will likely become an issue in coming decades. The displacement of Western countries by developing countries as the leading mineral producers has major geopolitical implications, because Europe is dependent on foreign supplies to satisfy its industrial demand. It was of concern that scarce-minerals markets could be transformed from equal-access competitive bidding markets to markets where trade is conducted by long-term supply agreements between major corporations with heavy government involvement, resulting in a politicized mineral supply (Kooroshy and others, 2010, p. 42, 89–93).

Chromite Ore.—Dutta (2010) reported that India, like China, Germany, and the United States, classifies chromite ore as a strategic raw material. India has been restricting the export of chromite ore. The United States stockpiled chromite ore, which is currently being sold. China is investing in South Africa and Zimbabwe to gain access to ore supplies and is discouraging ferrochromium export via export duty. The European strategy emphasizes conservation and recycling. South Africa, the leading exporter of chromite ore, has threatened to restrict chromite ore exports by imposing export duties to encourage domestic vertical integration.

The chromium industry relationship between China and South Africa was observed by Xstrata plc to be complementary for chromite ore and competitive for ferrochromium. The complementary nature of the chromite ore industry between China and South Africa resulted from the fact that China consumed much more chromite ore than it could produce, while South Africa produced much more chromite ore than it consumed. The competitive nature of the ferrochromium industry between China and South Africa resulted from the fact that both China and South Africa produced ferrochromium. China's ferrochromium industry is not a threat to that of South Africa because South Africa is a lower cost producer (Xstrata plc, 2010). China, as the leading consumer of chromium materials, and South Africa, as the leading producer of chromium materials, were expected to reach an accommodation through trade and investment.

Chromium Chemicals.—Major chromium chemical producers were China, Kazakhstan, Russia, South Africa, and the United States. Daijian (2010) reported that world annual production capacity of chromium chemicals was 1 Mt sodium dichromate equivalent. China had the leading capacity at 40% followed by Kazakhstan, 15%; the United States, 10%; Russia, 7%; South Africa, 6%; and India and Turkey, 5% each. China's chromium chemical production industry was down to 14 chromium chemical producers in 12 Provinces from more than 70 producers historically. China planned to consolidate production further to about 4 plants producing 50,000 to 100,000 t/yr during the next 5 years, improve environmental quality, and prohibit any new chromium chemical enterprises. China produced about 35,000 t-sodium dichromate equivalent in 2010. Diajian anticipated that chromium chemical consumption in China would reach 500,000 t/yr by 2020.

Stainless Steel.—International Stainless Steel Forum (2011) reported 31.1 Mt of world stainless steel production in 2010, a 27% increase compared with that of 2009. A review of stainless steel life cycle in 51 countries from 2000 through 2005 found the amount of stainless steel in use had increased by 30%. During the same time period, China accounted for almost one-half of world stainless steel production growth; global stainless steel recycling rate increased from 66% to 70%; the amount of stainless steel landfilled was unchanged; and the amount of stainless steel lost to other steel alloys increased from 9% to 12%. China was estimated to begin major discard flows in 2015 (Reck and others, 2010).

Ferrochromium.—Grigorieva (2010) reported that the volume of international ferrochromium trade decreased from 2008 to 2009 while China lost and the CIS gained market share. World stainless steel production declined; however, not as much as crude steel production. In 2009, the CIS produced about 1.4 Mt of ferrochromium and consumed about 200,000 t, leaving the balance for export. CIS ferrochromium producers had conveniently located, large, integrated plants producing quality products with low production costs. The CIS ferrochromium industry included SC Feral SRL (Tulcea, Romania); Chelyabinsk Electrometallurgical Integrated Plant (Chelyabinsk, Russia), which consumed chromite ore from CML (Australia) and JSC Kongor-Khrome (near Salekhard, Yamalo-Nenets Autonomous Region, Russia) (RFA International, LP, 2008); and Eurasian Natural Resources Corp. (ENRC) (United Kingdom), which produced ferrochromium in Kazakhstan at Aktobe Ferroalloy Plant, Aksu Ferroalloy Plant, and Serov Ferroalloy Plant, and chromite ore at Donskoy Ore Mining and Processing Plant.

Hobbs (2010) found that ferrochromium and stainless steel output fully recovered in 2010 from the global 2008–09 recession, and that the grade mix of stainless steel produced had shifted to 56% chromium-nickel, 28% chromium, and 16% chromium-manganese in 2010 from 72% chromium-nickel, 23% chromium, 5% chromium-manganese in 2001. In other words, chromium-nickel stainless steel lost market share mainly to chromium-manganese stainless steel. Chinese ferrochromium consumption drove the 2010 chromium market recovery and China was expected to be the leading consumer along with India in the foreseeable future.

World Review

European Union.—The European Union (EU) produced chromite ore, chromium metal and ferroalloys, and stainless steel. The EU was the third leading stainless steel producing area after China and Asia (excluding China). The leading stainless steel producers in the EU were Acerinox, S.A., Aperam S.A. (a wholly owned subsidiary of ArcelorMittal), ThyssenKrupp AG, and Outokumpu Oyj.

Stainless steel production has shifted from Europe to Asia, where the world's leading three producers, Tangshan Iron and Steel Co. (Taigang), Pohang Iron and Steel Co. Ltd. (POSCO), and Yieh United Steel Corp. (Yusco) were located. In addition, 13 of the top 20 stainless long products manufacturers were Asian. Chinese companies announced their expansion plans, and Chinese officials said that they were building now for demand in 5 to 10 years. By contrast, stainless producers in Europe and Japan operated at low capacity utilization and low profitability because demand was low. For China's competitors, the biggest concerns were that its lower cost and increasingly high-quality products will take over their export markets (Metal Bulletin Weekly, 2010b, p. 27).

The European Commission (EC) identified 14 of 41 raw materials and metals (relative to other materials and metals) as critical to the EU based on the geopolitical framework in which they are produced and consumed. The EC based criticality on importance to the EU economy and supply risk. Supply risk was based on environmental risk, concentration of production, recycling, and substitution. The EC was concerned that there would be inadequate supply to meet emerging-technology demand. Chromium was determined to be of highest economic importance, low supply risk, and low environmental country risk. The emerging technologies affecting demand for chromium were identified as seawater desalination and marine technologies. In addition to increasing demand resulting from the emerging technologies identified above, raw material and metal demand was expected to increase as the world economy grows. The EC recommended periodic critical raw material assessments; improvement of raw materials statistical information; EU policies that improved access to primary raw materials resources including land access, trade, and investment; encourage recycling; substitution; and efficient use (European Commission, 2010a, p. 37–43; b, p. 5, 6, 12–14, 19, 23, 34–39, 43, 47).

The European Chemicals Agency proposed four chromium compounds—ammonium dichromate, potassium chromate and dichromate, and sodium chromate—for public consultation as 'substances of very high concern' as part of its Registration, Evaluation, Authorization and Restriction of Chemical Substances legislation. Sodium chromate was used in the production of other chromium compounds, potassium chromate was used in metals coating, ammonium dichromate was used in the treatment of metals, and potassium dichromate was used in the manufacture of chromium metal. The chromium compounds were proposed for consultation by the Danish, French, and German governments (Metal Bulletin Daily, 2010c, p. 3).

Albania.—ACR Albanian Chrome [a subsidiary of DCM DECOmetal GmbH (Austria)] produced ferrochromium for export at its Elbasan smelter using chromite ore from Bulqiza Mine. ACR planned to upgrade the Bulqiza Mine and Elbasan smelter and renovate the ferrochromium smelter at Burrel. ACR would increase its ferrochromium production capacity to 72,000 t/yr from the current 36,000 t/yr with the addition of a third furnace at Burrel (Metal Bulletin Daily, 2010b; SBB Daily Briefing, 2010).

Australia.—The Government of Western Australia reported chromite ore sales by calendar year in contained Cr_2O_3: 2010, 73,618 t-Cr_2O_3; 2009, 72,813 t-Cr_2O_3 (Government of Western Australia, 2011, p. 20).

Weld Range Metals Ltd. started a study to determine the feasibility of exploiting 63.5 Mt of inferred mineral resource containing 4% chromium, 38.1% iron, and 0.38% nickel in Western Australia. Weld Range planned to mine 600,000 t/yr of ore to produce 310,000 t/yr of refined iron-chromium-nickel alloy starting in 2015 subject to affirmative feasibility and completion of capital raising (Weld Range Metals Ltd., 2010).

Brazil.—Brazil produced chromite ore, ferrochromium, and stainless steel. Brazil reported 2009 chromite ore production of 365,210 t (140,786 t Cr_2O_3-content), exports of 75,334 t, and imports of 11,953 t. Brazil produced from chromite ore reserves of 3.824 Mt Cr_2O_3-content, mostly in Bahia State. In 2009, Brazil produced 131,048 t of chromium ferroalloys, exported 5,063 t, and imported 6,030 t (Ramos, 2010).

Canada.—Cliffs Natural Resources Inc. (United States) (2011, p. 3, 5) reported that its chromite ore resources in Ontario were in the prefeasibility stage of development. Having completed the acquisition of Freewest Resources Canada Inc. and Spider Resources, Inc. Cliffs owned 100% of the Black Thor and Black Label properties and 74% of the Big Daddy property in 2010. Cliffs planned to produce from 1 to 2 Mt/yr of chromite ore out of which it would produce from 400,000 to 800,000 t/yr of ferrochromium.

China.—China produced chromite ore, chromium chemicals and metal, ferrochromium, and stainless steel. In 2010, China was the leading producer of stainless steel, which made it the leading market for ferrochromium. China also produced a small amount of chromite ore and a moderate amount of ferrochromium, mostly from imported chromite ore. China imported 6.76 Mt of chromite ore and 2.2 Mt of ferrochromium. China's chromium apparent consumption was 3.2 Mt (about 15% of world production). The Stainless Steel Council of China Special Steel Enterprise Association reported stainless steel production of 11.26 Mt in 2010, and the stainless branch of the China Metal Trade Association reported 14 Mt (Metal Bulletin Daily, 2011).

At yearend 2008 (the latest year for which data were available), China had chromite ore reserves of 1.98 Mt distributed among Gansu, Inner Mongolia, Tibet, and Xinjiang. China's annual chromite ore production has been between 220,000 t and 250,000 t. From 2002 through 2009, world chromium ore imports increased to 9.89 Mt, a growth rate of 220%, while China's imports increased to 6.76 Mt, a growth rate of 493%. In 2009, China accounted for 68% of global chromite ore trade. Since 2006, Oman, South Africa, and Turkey have increased their share of the Chinese market, and India and the rest of the world share has decreased. In 2009, China produced 1.81 Mt of ferrochromium from 70 plants whose total capacity was 3.2 Mt. Production was 600,000 t from Sichuan, 370,000 t from Shanxi, and 370,000 t from Inner Mongolia. From 2006 through 2009, China ferrochromium production has grown at an average annual rate of 26.6%. China imported 2.16 Mt of high-carbon ferrochromium in 2009 reaching a growth rate of 191% since 2006 (Hailiang, 2010).

Eurasian Natural Resources Corp. PLC (ENRC) (United Kingdom) reported production of 28,000 t of ferrochromium at its Tuoli plant in 2010 (Eurasian Natural Resources Corp. PLC, 2011, p. 22, 46).

Chinese mining companies have been securing raw material resources outside China. China Minmetals, Sinosteel, and Jiuquan Iron and Steel, which are entirely parastatal companies, have made joint-venture agreements with South African companies to produce chromium raw materials needed by China's steel industry. Some industry analysts expressed concern that China's expansion into raw material resource production could, in the long term, undermine the free market system that has provided raw materials, and lead to uncertain access to strategic minerals through the politcalization of the mining industry in mineral-producing countries. Limited supply of critical raw material resources could cause increased chances for conflict (Burgess, 2010; Campbell, 2010; Pariser, 2010, p. 3).

Bielski (2010) anticipated that China's steel compound growth rate would be 7.9% after 2010 from 17.1% during the 2000–10 time period (stainless steel, 8.3% after 2010 from 35.8%). Increased urbanization in China was expected to lead to stainless steel production in 2020 of 25 Mt resulting in domestically produced raw material supply becoming exceptionally tight, and security of supply becoming an issue. Raw material growth in developed markets was constrained by limited exploration during the past 20 to 30 years, environmental costs, power and infrastructure limitations, skilled labor shortages, and rising fiscal and trade duties and taxes. China needed to accelerate its raw materials supply capacity investments, increase scrap supply, and find materials substitutes.

Based on gross domestic product, China's economy increased fourfold since 1998. In 2010, China displaced Japan as the second leading economy. Since 1992, China has become the world's leading national consumer of many raw materials and must make up the gap between domestic production and consumption through imports, making China increasingly import dependent and at risk of potential severe raw materials shortage that could interrupt its economic development. While most national economies experienced negative metal consumption growth in 2009 resulting from the recession that followed the banking crisis of 2008, China's economy reached record import levels for selected metal commodities and showed double digit year-on-year consumption growth. While China has increased domestic steel consumption, mostly for its domestic construction industry, it did so based on only 20% domestically produced iron ore. As China's raw materials import dependence has increased, so has its overseas foreign direct investment, a large portion of which is in the resource sector. From 2008 to 2009, China moved from 13th to 6th ranked by foreign direct investment outward flows, and China holds the world's largest national currency reserves, with which it can invest. Wath (2010) expected Australia and Africa to receive greater investment attention from China.

Wenzhang (2010) anticipated China's crude steel production would increase until about 2012–13, at which time China's per capita income would reach about $5,000 per person. Historically, it has been at this point that crude steel production peaked in the economies of France, Germany, Japan, and the United States. In 2012, China's crude steel production would be 680 Mt; consumption would be 650 Mt.

The leading stainless steel producers in China were Baoshan Iron and Steel (Group) Corp. (Baosteel) [Baogang Group], Lianzhong Stainless Steel Corp., Shanghai Krupp Stainless Co., Ltd., Tangshan Iron and Steel Co. (Taigang) (Hebei Iron and Steel Group Co.), and Zhangjiang Pohang Stainless Steel Co., Ltd. China's stainless steel melting capacity could reach 23 Mt/yr by 2015 at which time consumption was expected to be 14 Mt/yr necessitating China's finding export markets for the excess production so that it could keep its stainless mills running at a reasonable rate (Metal Bulletin Weekly, 2010a, p. 25–26).

Shiguo (2010) reported that China planned to renovate its ferroalloy industry. In 2009, with 20% of world population, China accounted for 44% of iron and steel production and more than 60% of world ferroalloy production. As China's per capita income moved from $1,000 to about $4,000 in 2009, ferroalloy demand increased. It is China's goal to consolidate ferroalloy production into higher efficiency, less polluting, rationally located ferroalloy plants. The current goal is computer controlled, semiclosed furnaces with electrical capacity of 25,000 kilovolt-ampere or greater that consume less energy and raw materials per unit of production.

Finland.—Finland produced chromite ore (Kemi Mine), ferrochromium (Tornio Works), and stainless steel (Tornio Works). Outokumpu produced 0.598 Mt of marketable chromite ore from 1.3 Mt of run-of-mine ore and 0.238 Mt of ferrochromium compared with 0.247 Mt of chromite ore from 0.9 Mt of run-of-mine ore and 0.123 Mt of ferrochromium in 2009. The company reported proven reserves of chromite ore at

36 Mt graded at 26% Cr_2O_3, and indicated resources of chromite ore at 13 Mt graded at 30% Cr_2O_3, and inferred resources of chromite ore at 74 Mt graded at 29% Cr_2O_3 (Outokumpu Ojy, 2011, p. 37).

Best available technology applied to ferrochromium and stainless steel integrated plant production improved profitability, reduced CO_2 emissions, and provided clean and safe working conditions at Outokumpu's Tornio works. The use of preheated pellets reduced power consumption for ferrochromium production to 3,470 kWh per ton of ferrochromium produced (Kauppi, 2010).

Germany.—Elektrowerke Weisweiler GmbH [owned by Ruukki Group (Finland)] produced 17,994 t of ferrochromium in 2010 compared with 14,074 t in 2009 from a production capacity of 30,000 t/yr (Ruukki Group plc, 2011, p. 5, 12).

German industry relies on imported raw materials supply, which emerging technologies will convert into high-tech, cutting edge products. Chromium was among 15 vulnerable raw materials for German manufacturing industry. Thirty-two emerging technologies were analyzed for their impact on these vulnerable materials. German economic development depends on secure supply of stably priced raw materials (Angerer and others, 2009, p. 1, 2, 9–13).

India.—India produced chromite ore, chromium chemicals, ferrochromium, and stainless steel. India exported lumpy and friable chromite ore and chromite ore concentrates. India reported that 22 mines collectively produced 3.98 Mt of chromite ore in fiscal year 2008–09 (April 1, 2008, through March 31, 2009) compared with 4.87 Mt from 20 mines in fiscal year 2007–08, from chromite ore reserves of 53.9 Mt as of January 4, 2010. India reported chromite ore exports of 1.90 Mt in fiscal year 2008–09, compared with 0.907 Mt in fiscal year 2007–08 (Indian Bureau of Mines, 2010a, c). From an installed production capacity of 1.30 Mt/yr, India produced 0.817 Mt of ferrochromium in fiscal year 2008–09 compared with 0.949 Mt in fiscal year 2007–08. India exported 492 Mt of ferrochromium in fiscal year 2008–09 compared with 483 Mt in fiscal year 2007–08 (Indian Bureau of Mines, 2010b). The Geological Survey of India described many chromite ore deposits that it had explored (Geological Survey of India, 2010).

The leading Indian chromite ore and (or) ferrochromium producers were Balasore Alloys Ltd., Ferro Alloys and Minerals Division of Tata Steel Ltd., Ferro Alloys Corp., IDCOL Ferrochrome and Alloys Ltd., IMFA Group, JSL Ltd., Orissa Mining Corp. Ltd., Pradhan Industries Public, Rohit Ferro-Tech Ltd., and VISA Steel Ltd.

Kazakhstan.—In 2009, Donskoy produced 3.333 Mt of chromite ore from 225.8 Mt of reserves and operated two 700,000-t/yr beneficiation and pelletizing plants; the Aktobe ferrochromium plant produced 300,000 t of high-carbon ferrochromium, 26,000 t of medium-carbon ferrochromium, and 17,000 t of low-carbon ferrochromium; and the Aksu ferrochromium plant produced 686,000 t of high-carbon ferrochromium, and 52,000 t of ferrochromiumsilicon (Vulis, 2010).

ENRC produced chromite ore at Donskoy Mining Complex from production capacity of 3.5 Mt/yr. ENRC reported salable chromite ore production of 3.574 Mt in 2010 compared with 3.398 Mt in 2009 (of which Serov accounted for 65,000 t) and 3.629 Mt in 2008 (of which Serov accounted for 77,000 t). ENRC produced ferrochromium at Aksu, Aktobe, Serov Ferroalloy Plant JSC (Russia), and Tuoli (China) plants. ENRC reported ferrochromium production of 1.44 Mt in 2010, compared with 1.161 Mt in 2009 and 1.196 Mt in 2008, typically with 69% chromium content, of which in 2009, 105,000 t at Serov Ferroalloy Plant JSC (Russia) and 28,000 t at Tuoli (China). At Aktobe, where ENRC operated a gas-fired electrical powerplant, ENRC started construction of four new direct current furnaces with collective ferrochromium production capacity of 440,000 t/yr at an estimated cost of $750 million. The new production capacity was to replace a portion of the old production capacity, which was to be retired. For Donskoy GOK, ENRC reported Joint Ore Reserves Committee (JORC) compliant chromite ore reserves of 225.8 Mt at 41.5% Cr_2O_3 and resources of 322.2 Mt at 49.2% Cr_2O_3 as of December 31, 2009 (Eurasian Natural Resources Corp. PLC, 2010, p. 21–22, 115–119; 2011, p. 22, 46).

Mechel OAO (Russia) owned Oriel Resources (United Kingdom), which produced chromite ore at Voskhod Mine. Mechel reported JORC and NI 43–101 compliant proven (0.9 Mt) plus probable (17.4 Mt) chromite ore reserves at an average grade of 42.2% Cr_2O_3 as of December 2010 (Mechel OAO, 2010, p. 110).

Nigeria.—Chromite ore from the Anka area, Zamfara State, of Nigeria was characterized and beneficiated using magnetic separation. Beneficiated chromite ore was found to contain 48% Cr_2O_3 with chromium-to-iron ration of 6.2:1. Abubakre and others (2007) found that the chromite ore was successfully upgraded to meet specifications for metallurgical use by conventional ore dressing methods. Rhodium Ltd., an indigenous prospecting and development company, investigated the Dambagudu Chromite Deposit, which is near Talata-Mafara, Zamfara State (Rhodium Ltd., undated).

Oman.—Al Tamman Trading Establishment LLC (a wholly owned subsidiary of Muscat Overseas Group) operated two chromite mines—Al Ram Chromite and Wadi Rajmi Chromite projects. Al Ram produced about 12,000 metric tons per month (t/mo) at an average grade of 38% Cr_2O_3 and Wadi Rajmi produced 5,000 t/mo, 32% Cr_2O_3 (Al Tamman Trading Establishment LLC, 2010). Muscat Overseas Group formed a joint-venture agreement with Indsil Group (Indsil Energy & Electrochemicals Ltd. and Indsil Hydro Power & Manganese Ltd.) to build a plant in Oman with ferrochromium production capacity of 75,000 t/yr (Indsil Group, 2010). Hatton FZE reported chromite ore production of about 480,000 t/yr from the Somail region (Hatton FZE, undated). Northern Minerals Co. LLC reported chromite ore production in the Batinah and Dakhiliya Regions (Northern Minerals Co. LLC, undated).

Russia.—Russia produced chromite ore, chromium chemicals and metal, ferrochromium, and stainless steel. ENRC produced chromite ore at Saranovskaya Mine 'Rudnaya' JSC and ferrochromium at Serov Ferroalloy Plant JSC. ENRC reported Saranovskaya chromite ore production of 65,000 t in 2009 compared with 77,000 t in 2008 and Serov ferrochromium production of 105,000 t in 2009 (Eurasian Natural Resources Corp. PLC, 2010, p. 21).

Mechel acquired the Tikhvin Ferroalloy Smelting Plant Closed Joint-Stock Co. through the acquisition of Oriel Resources plc (United Kingdom) in 2008. Mechel produced 455,800 t of ferrochromium in 2010 compared with 400,700 t in 2009 at 4 plants—Chelyabinsk Electro-Metallurgical Plant OAO (211,600 t compared with 207,700 t), Chelyabinsk region; Serov Ferroalloys Plant OAO (167,500 t compared with 92,700 t), Sverdlovsk region; Tikhvin Ferroalloy Plant ZAO (72,100 t compared with 95,200 t), Leningrad region; and Klyuchevsk Ferroalloys Plant OAO (4,600 t compared with 5,100 t), Sverdlovsk region (Mechel OAO, 2010, p. 52, 108; 2011, p. 111).

South Africa.—South Africa was a leading chromite ore and ferrochromium producing country and produced chromium chemicals and stainless steel. Among issues confronting the South African chromium industry were electrical power generation and logistics. Leading producers of chromite ore and (or) ferrochromium in South Africa were African Rainbow Minerals Ltd., ASA Metals (Pty.) Ltd., Assore Ltd., Chromex Mining plc, Hernic Ferrochrome (Pty.) Ltd., International Ferro Metals Ltd., Lanxess (Pty.) Ltd., Merafe Resources Ltd., Samancor Chrome Ltd., Tata Steel Ltd., and Xstrata plc.

South Africa's Council for Mineral Technology (Mintek) conducted Government- and commercial-sponsored research and development on chromite ore and ferrochromium. Mintek developed mine-specific processes for chromite ore beneficiation, developed platinum recovery process applied to chromite ore tailings, developed furnace controller technology for ferrochromium-producing furnaces, and developed stainless steel dust recycling technology. Mintek reported a furnace-control and optimization system for an 80 megavoltampere furnace at Kazchrome's Aksu ferroalloy plant in Kazakhstan (Mintek, 2010).

Platinum-group minerals (PGM) are found in the Merensky and UG2 reefs; however, the UG2 reef contains substantially more chromite. After the extraction of PGM, chromite is left in the tailings. PGM mining of the UG2 reef has increased, because mining is less costly and better technologies are available to treat the chromite-rich ore. Increased demand for chromite for export and as a low-cost chromite to supplement mined chromite for smelting, now that pelletizing and sintering technologies for chromite fines are common, have made these tailings useable. Machingawuta (2010) reported that acceptance of ferrochromium containing less than 50% chromium also contributes to UG2 tailings processing, because those tailings produce ferrochromium containing 49.5% chromium. Aiken (2010) reported that UG2 chromite contains 10% to 25% Cr_2O_3, which can be beneficiated to 40% to 42% Cr_2O_3 after extraction of PGM. UG2 platinum reserves are about 1.3 billion metric tons held by Anglo American Platinum (51%), Impala Platinum (25%), Lonmin Platinum (20%), and Aquarius Platinum Ltd. (4%). Aiken estimated chromite ore production from UG2 tailings to be 3 Mt/yr with 1.4 Mt in the building phase, and an additional 1.3 Mt possible in 2012–13. Aquarius Platinum, GB Mining, and Sylvania South Africa operated a chromite tailings retreatment plant (CTRP) adjacent to Aquarius' Kroondal (platinum) Mine where chromite mine tailings were treated to recover platinum. Aquarius restarted production at its Everest (platinum) Mine where it processed UG2 tailings in its Spiral Retreatment Plant (SRP). SRP chromite production capacity was 200,000 t/yr at a grade of 40% Cr_2O_3 (Aquarius Platinum Ltd., 2010, p. 10, 25, 82). Lonmin Platinum planned chromite recovery from UG2 platinum tailings in a joint venture with Xstrata-Merafe and ChromTech (Metal Bulletin Daily, 2010d, p. 3).

As result of the commodity boom that started circa 2004, AMCOL found the supply of wet bulk chromite it used to make foundry sand difficult to maintain, so it acquired controlling interest in Batlhako Mining Ltd. (Ruighoek Mine) in 2009 and acquired the remaining interest in 2010. AMCOL found that by carefully milling run-of-mine LG6 chromite ore followed by dry separation and classification, it could get 70% yield of a low silicate product with size range of 25 to 70 American Foundry Society (AFS) while reducing power and water use (Castanga and Howden, 2010). AMCOL International Corp. (United States) had purchased 53% interest in the Ruighoek Chrome Project from Pacific Niugini Ltd. [formerly Chrome Corp. Ltd. (Australia)] in 2009. AMCOL purchased the remaining 47% in 2010. AMCOL reported that production of ferrous castings for automobile and industrial equipment in China and the United States, AMCOL's two largest markets, rebounded in 2010. In 2010, AMCOL started up a new chromite ore processing plant to produce foundry sand (AMCOL International Corp., 2011, p. 4; Pacific Niugini Ltd., undated). AMCOL reported that basic to neutral pH, broad sieve distribution, high melting point, high thermal conductivity, low thermal expansion, and wetability resistance to molten steel were among the unique combination of chromite sand properties that produce a better surface finish and reduced the likelihood of casting defects (AMCOL, undated).

Marico Chrome Corp., a 50–50 joint venture between Vereenging Refractories and Samancor Chrome SA, produced refractory and metallurgical chromite ore from the Marico chromite deposit of the Bushveld Complex at the rate of 40,000 t/yr from a run-of-mine reserve of 9 Mt, where Marico has been producing metallurgical- and refractory-grade chromite ore since 1956 from the LG6, MG, and UG2 layers. Refractory-grade ore contained up to 49% Cr_2O_3, less than 1% silicon dioxide, and a chromium-to-iron ratio of 2:1. Refractory characteristics of chromite were identified as high melting temperature, moderate thermal expansion, neutral chemical behavior, and high corrosion resistance (McEwan, 2010; McEwan and others, 2011).

Ruukki Group entered the chromium industry through acquisition of chromite ore mining resources and ferrochromium production facilities in South Africa [Mogale Alloys (Pty.) Ltd., a South African producer of ferrochromium and other ferroalloys] and Zimbabwe after Kermas Group became its largest shareholder in 2008. Kermas Group, as of February 2006, operated as a subsidiary of Kluchevsky Ferroalloy Plant OAO and was based in the United Kingdom, manufactured ferrochromium and chromium chemicals in Russia, ferrochromium in Germany, and chromite ore in Turkey (Bloomberg Businessweek, undated). Ruukki acquired Chromex Mining plc (United Kingdom), which produced chromite ore from the Stellite Mine and was developing the Mecklenburg

Mine in South Africa and held interest in Waylox Mining (Pvt) Ltd. in Zimbabwe (Ruukki Group plc, 2011, p. 4–5, 9–10). Ruukki planned to add two DC arc furnaces at Mogale Alloys that would double ferrochromium production capacity to 280,000 t/yr (Metal Bulletin Weekly, 2010c, p. 7).

Tharisa Minerals (Pty.) Ltd. reported reserves of about 74 Mt of chromite ore and planned to produce at a rate of 5.5 Mt/yr from an open pit that would yield 1.6 Mt/yr of chromite ore concentrate. Tharisa reported that it would double chromite ore concentrate production to 0.42 Mt (Clark, 2008; 2009).

Sweden.—Sweden produced ferrochromium and stainless steel. Vargön Alloys AB, a Yildirim Group (Turkey) company, produced ferrochromium from a ferrochromium production capacity of about 220,000 t/yr. Vargon suspended ferrochromium deliveries after heavy snowfall caused roof collapses at its production and warehouse facilities (Metal Bulletin Daily, 2010d, p. 1).

Turkey.—Turkey produced chromite ore, chromium chemicals, and ferrochromium. Eti Krom Inc., a Yildirim Group company, produced chromite ore and high-carbon ferrochromium. Eti Krom's ferrochromium production capacity was 50,000 t/yr. Eti Krom planned to complete renovation of two furnaces that would add 100,000 t/yr to its production capacity (Eti Krom Inc., 2010). Harsh winter conditions and heavy snowfall in Turkey interrupted train service between Elazig, the location of Eti Krom's smelter and near to its chromite ore mines, and the ports of Iskenderun and Mersin, causing Eti Krom to declare force majure.

Eti Elektrometalurji A.S. produced chromite ore and high- and low-carbon ferrochromium near Antalya from a production capacity of 13,000 t/yr low-carbon ferrochromium and 10,000 t/yr high-carbon ferrochromium (Eti Elektrometalurji A.Ş., undated). Türk Maadin Sirketi A.Ş. (TMS) [a subsidiary of Ruukki Group plc (Finland)] acquired Intermetal Madencilik ve Ticaret A.Ş. TMS produced 54,917 t of chromite in 2010 compared with 25,774 t in 2009 (Ruukki Group plc, 2011, p. 12, 46).

Çevikler Mermer San. ve Tic. Ltd. Şti., Dedeman Madencilik Sanayi ve Ticaret AS, and Eti Krom Inc. were the leading chromite ore producers with Eti Krom producing about 1 Mt/yr and the other two producing about 0.3 Mt/yr each (Metal-Pages, 2008). Çevikler Group reported that it mined chromite ore via its subsidiary Çevikler Mermer San. ve Tic. Ltd. Şti., which it exported with chromite ore from other producers. Çevikler mined chromite ore in the Pınarbasi District of Kayseri Province (Çevikler Group, undated). Eti Krom reported that it operated 79 mines, mostly in Elazig Province but also in Adana, Diyarbakir, Hatay, Kayseri, Malatya, and Mugla Provinces from proven plus probable reserves of 250 Mt (Eti Krom Inc., undated).

Zimbabwe.—Zimbabwe's ferrochromium industry comprised Maranatha Ferrochrome (Private) Ltd., Oliken Ferro Alloys (Private) Ltd., Zimasco (Private) Ltd., and Zimbabwe Alloys. Chromite ore for these smelters was supplied by Caesar, Darwendale, Inyala, Lalapanzi, Mapanzure, Ngezi, Fhonda-Mumo, Southridge, Sutton, United, and Vanad Mines, and Inyala and Sutton heavy-media separation plants. Chromite ore graded between 40% and 55% Cr_2O_3 with chromium-to-iron ratio of 2.0 to more than 3.3. Zimasco produced high-carbon ferrochromium from a capacity of 220,000 t/yr; Zimbabwe Alloys, 146,000 t/yr of high-carbon ferrochromium, 29,200 t/yr of ferrochromium-silicon, and 40,200 t/yr of low-carbon ferrochromium; and other producers, 55,000 t/yr of high-carbon ferrochromium, yielding a collective 490,000 t/yr of chromium ferroalloys. Planned expansions were expected to bring chromium ferroalloy production capacity to 588,000 t/yr in Zimbabwe.

Zimasco (Private) Ltd., a vertically integrated ferrochromium producer co-owned by Sinosteel (China), China-Africa Development Fund (China), and ZCE Finance (SFV) (Mauritius), produced at Kwekwe from a high-carbon ferrochromium production capacity of 180,000 t/yr from six furnaces, one of which was not operational. Zimasco was supplied with chromite ore from its mines and other mines along the Great Dyke of Zimbabwe. Zimasco planned to increase its ferrochromium production capacity (Metal-Pages, 2010).

Maranatha Ferrochrome (Private) Ltd. produced high-carbon ferrochromium at Eiffel Flats near Kadoma in Mashonaland West Province. RioZim Ltd. (a subsidiary of Rio Tinto) planned a joint venture with Maranatha to produce 30,000 t/yr of ferrochromium based on chromite holdings in the Darwendale area (Njini, 2010). RioZim Ltd. (2011, p. 12) explored for JORC compliant resources and planned to set up a chromite ore concentration operation.

Outlook

After the 2008 financial crisis that put the chromium industry into recession in 2009, 2010 was a year of recovery. World chromite ore, ferrochromium, and stainless steel production decreased from 2008 to 2009; and then increased from 2009 to 2010 with 2010 production of ferrochromium and stainless steel exceeding that of 2008, leading to the expectation that chromite ore production would continue to increase.

Agnello (2010) reported that foundry-grade chromite, which accounted for 3% of global chromite ore consumption, was used as core and molding sands, initially used in manganese steel casting, and has moved to the manufacture of alloy and carbon steel castings and nonferrous metal castings. Since 1970, about 70% of foundry capacity in developed countries closed, resulting in a shift of casting to Southeast Asia and developing countries. Refractory-grade chromite is used more in shaped-refractory (80%) than in monolithic products. Magnesite-chromite refractories are preferred in nonferrous metallurgy (such as copper, lead, and zinc refining); however, the cement, lime, and glass industries have moved away from using magnesite-chromite bricks because of environmental considerations associated with the disposal of used refractories. About 850,000 t of sodium dichromate was produced in 2008 from about 1.25 to 1.3 Mt of chromite ore. The sodium dichromate was converted to chromium oxide (34%), chromic acid (29%), chromium sulfate (23%), and other chemicals (14%). Agnello forecast of chromium sulfate production, which is used in leather manufacturing, to increase between 1% and 1.5%; chromic acid, which is used in metal finishing and to preserve wood, to increase between 3% and 3.5%, and chromium oxides, which are used in alloy, ceramic, and pigment manufacture, to increase between 2% and 3%.

Historically, three events outside of the chromium industry (the dissolution of the Soviet Union, the economic growth of China, and the world financial crisis in 2008–09) have had significant impacts on the chromium industry, making industry analysts and company planners sensitive to the potential for such events.

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TABLE 1

SALIENT CHROMIUM STATISTICS[1]

		2006	2007	2008	2009	2010
World, production, contained chromium:						
Chromite ore (mine)[2]	metric tons	6,080,000	7,030,000 [r]	7,390,000 [r]	6,000,000 [r]	7,290,000
Ferrochromium (smelter)[3]	do.	4,180,000 [r]	4,790,000 [r]	4,590,000	4,000,000 [r]	4,960,000
Stainless steel[4]	do.	4,820,000	4,730,000	4,410,000	4,180,000	5,300,000
U.S. supply:						
Components of U.S. supply, contained chromium:						
Domestic mines	do.	--	--	--	--	--
Secondary[5]	do.	179,000	162,000	146,000	141,000	144,000
Imports:						
Chromite ore[2]	do.	53,800	46,400	64,300	23,000	43,900
Chromium chemicals	do.	12,100	10,600	18,000	10,600	5,120
Chromium ferroalloys	do.	265,000	259,000	307,000	140,000	305,000
Chromium metal	do.	10,900	11,700	13,100	7,570	13,000
Stainless steel mill products and scrap	do.	179,000	158,000	157,000	91,800	133,000
Stocks, January 1:						
Government	do.	375,000	253,000 [6]	115,000	155,000 [7]	129,000
Industry[8]	do.	8,520	9,620	9,940	7,290	6,820
Total	do.	1,080,000	910,000	831,000	576,000	779,000
Distribution of U.S. supply, contained chromium:						
Exports:						
Chromite ore[2]	do.	17,400	12,000	2,280	743	1,390
Chromium chemicals	do.	16,700	21,000	22,600	13,500	21,600
Chromium ferroalloys and metal	do.	22,300	27,000	11,300	2,900	4,850
Stainless steel mill products and scrap	do.	156,000	231,000	250,000	263,000	246,000
Stocks, December 31:						
Government	do.	272,000 [6]	115,000	105,000 [9]	129,000	115,000
Industry[8]	do.	9,620	9,940	7,290	6,820 [r]	7,300
Total	do.	493,000	416,000	399,000	416,000	396,000
Production, reported, chromium ferroalloy and metal net production[10]		W	W	W	W	--
Consumption:						
Apparent, contained chromium	do.	589,000	493,000	432,000	160,000	383,000
Reported:						
Chromite ore and concentrates, gross weight	do.	W	W	W	W	W
Chromium ferroalloys:[11]						
Gross weight	do.	429,000 [r]	469,000 [r]	427,000	383,000 [r]	434,000
Contained chromium	do.	252,000 [r]	275,000 [r]	251,000	224,000 [r]	248,000
Chromium metal, gross weight	do.	6,160	5,410	4,740	4,190 [r]	4,540
Stocks, December 31, gross weight:						
Government:[6]						
Chromite ore	do.	1,160	--	--	--	--
Chromium ferroalloys	do.	373,000	155,000	140,000 [9]	175,000	154,000
Chromium metal	do.	5,290 [r]	4,970	4,820	4,670	4,670
Industry:						
Producer[12]	do.	W	W	W	W	W
Consumer:						
Chromium ferroalloys[13]	do.	15,500	16,300	11,700	11,400	11,500
Chromium metal	do.	220	221	235	160	284
Other	do.	231	216	272 [r]	263	243
Prices, average annual:						
Chromite ore[14]	dollars per metric ton	119	244	346	159 [r]	208
Ferrochromium, chromium content[15]	dollars per pound	0.695	1.048	1.748	0.806	1.261
Electrolytic chromium metal, gross weight[16]	do.	4.50	NA	NA	NA	NA
Aluminothermic chromium metal, gross weight[17]	do.	2.94	3.66	5.30	4.08	5.23

See footnotes at end of table.

TABLE 1—Continued
SALIENT CHROMIUM STATISTICS[1]

		2006	2007	2008	2009	2010
Value of trade:[18]						
Exports	thousands	$121,000	$150,000	$149,000	$86,600	$131,000
Imports	do.	$529,000	$699,000	$1,430,000	$444,000	$1,010,000
Net imports[19]	do.	$408,000	$548,000	$1,280,000	$358,000	$883,000
Stainless steel:						
Production:						
Gross weight[20]	metric tons	2,460,000	2,170,000	1,930,000	1,620,000	2,200,000
Contained chromium[21]	do.	419,000	360,000	324,000	276,000	383,000
Average grade, dimensionless[22]		0.1705	0.1656	0.1684	0.1703	0.1738
Shipments, gross weight[23]	do.	1,890,000	1,700,000	1,380,000	1,200,000	1,510,000
Exports, gross weight	do.	410,000	476,000	471,000	414,000	508,000
Imports, gross weight	do.	872,000	809,000	783,000	416,000	585,000
Scrap, gross weight:						
Receipts	do.	1,050,000	953,000	858,000	832,000	846,000
Consumption	do.	1,500,000	1,430,000	1,330,000	1,260,000	1,280,000
Exports	do.	506,000	882,000	1,000,000	1,130,000	937,000
Imports	do.	180,000	118,000	140,000	124,000	195,000
Value of trade:						
Exports	thousands	$1,580,000	$2,110,000	$2,300,000	$1,450,000	$2,120,000
Imports	do.	$3,210,000	$4,300,000	$4,040,000	$1,710,000	$2,400,000
Scrap exports	do.	$716,000	$1,620,000	$1,190,000	$777,000	$936,000
Scrap imports	do.	$209,000	$198,000	$217,000	$138,000	$305,000
Net exports[19, 24]	do.	-$1,130,000	-$770,000	-$773,000	$384,000	$346,000

[r] Revised. do. Ditto. NA Not available. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Calculated assuming chromite ore to average 44% Cr_2O_3, which is 68.42% chromium.

[3] Calculated assuming chromium content of ferrochromium to average 57% chromium.

[4] Calculated from American Iron and Steel Institute reported stainless steel production assuming chromium content of stainless steel to average 16.7% chromium.

[5] Calculated assuming chromium content of stainless steel to average 17% chromium.

[6] "Summary of Commodities" as reported by the Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center through 2006. "Inventory Material" as reported by DLA starting in 2007 except where noted otherwise.

[7] From January 1, 2009 to December 31, 2009, the DLA made an accounting adjustment to low-carbon ferrochromium stocks making them (the stocks for those months) incompatible for the purpose of computing stock change for that year. January stocks were estimated.

[8] Includes consumer stocks of chromium ferroalloys and metal and other chromium-containing materials.

[9] From January 1, 2008 to December 31, 2008, the DLA changed its high-carbon and low-carbon ferrochromium stocks accounting method making them (the stocks for those months) incompatible for the purpose of computing stock change for that year. December stocks were estimated based on monthly stock change excluding the accounting-change month.

[10] Includes chromium ferroalloys and metal and other chromium materials in the United States.

[11] Chromium ferroalloy, chromite ore, and other chromium-containing materials excluding chromium metal.

[12] Producer stocks of chromium ferroalloys and metal.

[13] Consumer stocks of high- and low-carbon ferrochromium and ferrochromium-silicon.

[14] Time-weighted average price of South African chromite ore that contains 44% Cr_2O_3 f.o.b. South Africa as reported in Ryan's Notes in 2006. Annual average price of South African chromite ore that contains 44% Cr_2O_3 f.o.b. South Africa as reported by Ryan's Notes after 2006.

[15] Time-weighted average U.S. price of imported high-carbon ferrochromium that contains 50% to 55% chromium as reported in Platts Metals Week.

[16] Time-weighted average U.S. price of domestically produced electrolytic chromium metal as reported by Ryan's Notes.

[17] Annual average U.S. price of imported aluminothermic chromium metal as reported by Ryan's Notes.

[18] Includes chromite ore and chromium ferroalloys, metal, and chemicals.

[19] Negative data indicate that imports are greater than exports.

[20] Source: American Iron and Steel Institute annual report of stainless and heat-resisting raw steel production and shipments.

[21] Estimated mass-weighted average of the mean chromium content of stainless steel production by grade. Uncertainty is approximately ± 0.01, owing to the range of chromium chemical specification limits by stainless steel grade.

[22] Ratio of estimated mass-weighted average chromium content of stainless steel production by grade to production. Expressed as a fraction. Source: American Iron and Steel Institute quarterly reports of stainless and heat-resisting raw steel production by grade.

[23] Source: American Iron and Steel Institute annual report of stainless and heat-resisting raw steel shipments.

[24] Includes stainless steel and stainless steel scrap.

TABLE 2

U.S. REPORTED CONSUMPTION AND STOCKS OF CHROMIUM PRODUCTS[1]

(Metric tons)

	2009		2010		Change[2]	
	Gross weight	Chromium content	Gross weight	Chromium content	Quantity	Percentage
Consumption by end use:						
Alloy uses:						
Steel:						
Carbon steel	5,760	3,500	7,210	4,430	1,450	25
High-strength low-alloy steel	5,810	2,460 [r]	2,800	1,840	-3,010	-52
Stainless and heat-resisting steel	323,000	188,000	358,000	207,000	34,600	11
Full alloy steel	13,400	8,180 [r]	17,900	10,900	4,530	34
Unspecified steel[3]	26,900	16,800 [r]	27,800	17,400	821	3
Superalloys	8,630 [r]	6,820 [r]	9,390	7,480	762	9
Other alloys and uses[4]	3,110 [r]	2,000 [r]	4,690	3,180	1,580	51
Total	387,000 [r]	228,000 [r]	428,000	252,000	40,800	11
Consumption by material:						
Low-carbon ferrochromium	27,400 [r]	18,700 [r]	32,000	21,900	4,540	17
High-carbon ferrochromium	323,000	192,000	364,000	215,000	40,400	13
Ferrochromium silicon	(5)	(5)	(5)	W	W	W
Chromium metal	4,190 [r]	4,180 [r]	4,540	4,540	357	9
Chromium-aluminum alloy	355	219	371	256	16	4
Other chromium materials	31,700 [r]	12,900 [r]	27,100	10,700	-4,570	-14
Total	387,000 [r]	228,000 [r]	428,000	252,000	40,800	11
Consumer stocks:						
Low-carbon ferrochromium	1,790 [r]	1,220 [r]	1,810	1,240	19	1
High-carbon ferrochromium	8,580 [r]	5,090 [r]	9,210	5,450	634	7
Ferrochromium silicon	W	W	W	W	W	W
Chromium metal	149 [r]	149 [r]	284	283	135	91
Chromium-aluminum alloy	119	73	124	86	5	5
Other chromium materials	663 [r]	280 [r]	618	246	-45	-7
Total	11,300 [r]	6,820 [r]	12,000	7,300	749	7
National Defense Stockpile stocks:[6, 7]						
Chromium ferroalloys:[8]						
High-carbon ferrochromium	113,000	80,800	95,400	68,100	-17,700	-16
Low-carbon ferrochromium	61,500	43,900 [r]	59,000	42,200	-2,450	-4
Chromium metal[9]	4,670	4,670	4,670	4,670	--	--

[r] Revised. W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Change based on gross weight quantity of unrounded data of current year compared with that of previous year.

[3] Includes electrical, tool, and unspecified steel end uses.

[4] Includes cast irons, welding and alloy hard-facing rods and materials, wear- and corrosion-resistant alloys, and aluminum, copper, magnetic, nickel, and other alloys.

[5] Withheld to avoid disclosing company proprietary data; included in "Other chromium materials."

[6] The source for stockpile information is the Defense Logistics Agency, DLA Strategic Materials.

[7] The DLA data is based on the "Total Uncommitted Inventory" of stockpile material D–1 report.

[8] Chromium content estimated using 71.4% chromium.

[9] Chromium content estimated using 100% chromium.

TABLE 3

VALUE OF IMPORTS AND U.S. PRICE QUOTATIONS FOR CHROMIUM MATERIALS[1]

Material		2009		2010	
		Contained chromium	Gross weight	Contained chromium	Gross weight
Value:[2, 3]					
Chromite ore:					
Not more than 40% chromic oxide	dollars per metric ton	2,030	344	XX	XX
More than 40% but less than 46% chromic oxide	do.	1,980	621	537	168
46% or more chromic oxide	do.	641	203	793	252
Average	do.	762	227	674	212
Ferrochromium:					
Not more than 0.5% carbon	do.	4,490	3,040	4,630	3,180
More than 0.5% but not more than 3% carbon	do.	3,360	2,030	3,660	2,240
More than 3% but not more than 4% carbon	do.	1,000	540	1,850	1,100
Average (not more than 4%)	do.	4,230	2,800	4,540	3,090
More than 4% carbon	do.	1,540	844	2,290	1,320
Average (all grades)	do.	2,090	1,190	2,560	1,500
Chromium metal[4]	do.	XX	9,900	XX	11,300
Price:[5]					
Chromite ore:					
Turkey					
36% to 38% Cr_2O_3	do.	976	247	1,340	339
40% to 42% Cr_2O_3	do.	823	231 r	1,270	357
44% Cr_2O_3	do.	814	245	XX	XX
South Africa					
39% Cr_2O_3	do.	578 r	154 r	777	208
44% Cr_2O_3	do.	527 r	159 r	690	208
High-carbon ferrochromium:					
49% to 51% chromium	cents per pound	80.90	XX	117	XX
60% to 65% chromium	do.	81.60 r	XX	126	XX
Low-carbon ferrochromium:					
0.05% carbon	do.	235 r	XX	240	XX
0.10% carbon	do.	207 r	XX	216	XX
0.15% carbon	do.	190 r	XX	200	XX
Chromium metal:					
Imported, aluminothermic	do.	XX	408	XX	523

r Revised. do. Ditto. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Mass-weighted average based on customs value and weight of imported material.

[3] Reported by the U.S. Census Bureau.

[4] Average for all grades.

[5] Source: Ryan's Notes.

TABLE 4
U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2] code	Type	2009		2010		Principal destinations in 2010 (Quantity in metric tons, value in thousands)
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	
2610.00.0000	Chromite ore and concentrate, gross weight	2,500	$1,610	4,420	$2,620	Canada (2,810, $1,410); Mexico (1,390, $906); Venezuela (78, $57); Vietnam (31, $7); Colombia (28, $16); Thailand (26, $74); Philippines (20, $40); Taiwan (14, $11); China (12, $52); Ecuador (8, $26); Belgium (3, $8); Uruguay (1, $3); Hong Kong (1, $5); Spain (1, $4).
	Metal and alloys, gross weight:					
8112.21.0000	Unwrought chromium powders	213	4,570	291	6,570	Germany (67, $1,830); Japan (55, $1,020); Canada (44, $693); Mexico (39, $511); Taiwan (20, $428); China (19, $508).
8112.22.0000	Chromium metal waste and scrap	20	481	41	734	Taiwan (15, $283); Japan (11, $205); United Kingdom (7, $53); Singapore (3, $59); Malaysia (2, $40); Philippines (2, $38); Germany (1, $49).
8112.29.0000	Chromium metal other than unwrought powders and waste and scrap	179	8,250	265	11,100	Japan (70, $3,550); Canada (23, $222); Hong Kong (22, $787); Brazil (16, $627); Laos (14, $130); Singapore (12, $758); Russia (10, $271); United Kingdom (10, $256); Germany (10, $455); Taiwan (9, $1,180); China (9, $324); Czech Republic (7, $82); Ireland (7, $228).
	Total chromium metal	411	13,300	597	18,400	
	Chromium ferroalloys:					
7202.41.0000	High-carbon ferrochromium:[3]					
	Gross weight	3,200	4,270	6,530	7,810	Canada (2,980, $3,480); Mexico (2,010, $2,640); Brazil (756, $702); Peru (200, $192); India (114, $100); Italy (99, $160); Chile (87, $187); Argentina (61, $53); Taiwan (58, $51); Colombia (57, $52); New Zealand (44, $75); Thailand (43, $98); Philippines (27, $24).
	Contained weight	1,770	XX	3,150	XX	
7202.49.0000	Low-carbon ferrochromium:[4]					
	Gross weight	1,560	2,440	2,490	4,820	Canada (1,860, $3,490); Mexico (309, $576); Brazil (118, $268); Australia (64, $94); Netherlands (41, $96); Republic of Korea (41, $104); Thailand (20, $57); China (20, $57); Peru (13, $31); Colombia (8, $31); India (3, $3); Lebanon (1, $8).
	Contained weight	710	XX	1,060	XX	
7202.50.0000	Ferrochromium-silicon:					
	Gross weight	19	109	106	225	Mexico (60, $125); Canada (36, $46); Brazil (9, $49); Costa Rica (1, $6).
	Contained weight	6	XX	37	XX	
	Total chromium ferroalloys:					
	Gross weight	4,780	6,820	9,130	12,900	
	Contained weight	2,490	XX	4,250	XX	
	Chemicals, gross weight:					
	Chromium oxides:					
2819.10.0000	Chromium trioxide	10,100	18,600	14,700	30,700	Brazil (2,590, $5,410); United Kingdom (1,760, $2,870); China (1,750, $4,590); Republic of Korea (1,110, $2,180); India (1,100, $1,810); France (791, $1,690); Italy (518, $1,020); Spain (493, $829); Colombia (469, $1,120); Indonesia (452, $1,110); Belgium (435, $1,070); Chile (367, $628).

See footnotes at end of table.

TABLE 4—Continued
U.S. EXPORTS OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2] code	Type	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)	Principal destinations in 2010 (Quantity in metric tons, value in thousands)
	Chemicals, gross weight—Continued:					
	Chromium oxides—Continued:					
2819.90.0000	Other	1,900	$9,300	5,250	$26,000	Belgium (1,160, $4,500); Spain (1,050, $3,310); United Kingdom (619, $1,840); Canada (423, $2,480); Brazil (308, $1,240); China (270, $1,180); South Africa (194, $1,010); France (189, $2,170).
	Total chromium oxides	12,000	27,900	19,900	56,700	
2833.29.4000	Chromium sulfates	16	114	60	306	Mexico (25, $121); China (12, $61); Taiwan (5, $24); Congo (4, $20); India (4, $19); Singapore (3, $21); Turkey (2, $11); Argentina (2, $10); Hong Kong (1, $6); Venezuela (1, $10).
	Salts of oxometallic or peroxometallic acids:					
2841.90.4500	Zinc and lead chromate	56	293	35	362	Guatemala (18, $50); Jamaica (8, $43); Norway (2, $5); South Africa (2, $229); Trinidad and Tobago (2, $5); Costa Rica (2, $10); Barbados (1, $6); Brazil (1, $4).
2841.30.0000	Sodium dichromate	19,700	20,200	29,400	27,500	Japan (15,500, $14,500); Mexico (7,480, $5,710); Canada (3,790, $4,590).
2841.50.1000	Potassium dichromate	53	276	48	131	Brazil (24, $52); Mexico (7, $36); Germany (6, $9); Taiwan (4, $29); Angola (3, $3); Republic of Korea (3, $3).
2841.50.9100	Other	615	2,330	929	3,570	Republic of Korea (130, $477); China (110, $379); Vietnam (105, $478); Canada (102, $424); Thailand (84, $343); Indonesia (64, $105); India (55, $93); Taiwan (47, $120); Lithuania (38, $171); Russia (37, $59).
	Total salts	20,500	23,100	30,500	31,500	
3206.20.0000	Pigments and preparations, gross weight	1,220	13,800	2,540	8,640	Mexico (all).

XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] More than 4% carbon.

[4] Not more than 4% carbon.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF FERROCHROMIUM, BY COUNTRY[1]

	Not more than 0.5% carbon (HTS[2] code 7202.49.5090)			More than 0.5% carbon, but not more than 3% carbon (HTS[2] code 7202.49.5010)			More than 3% carbon, but not more than 4% carbon (HTS[2] code 7202.49.1000)			More than 4% carbon (HTS[2] code 7202.41.0000)			Total all grades		
Country	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)
2009:															
Albania	--	--	--	--	--	--	--	--	--	558	360	$714	558	360	$714
Austria	--	--	--	--	--	--	--	--	--	466	301	576	466	301	576
Belgium	--	--	--	--	--	--	17	12	$27	--	--	--	17	12	27
China	1,850	1,180	$4,730	160	98	$368	--	--	--	40	32	142	2,050	1,300	5,240
Germany	3,800	2,640	15,700	--	--	--	--	--	--	--	--	--	3,800	2,640	15,700
India	--	--	--	--	--	--	--	--	--	2,050	1,230	1,870	2,050	1,230	1,870
Japan	1,090	752	4,810	--	--	--	--	--	--	--	--	--	1,090	752	4,810
Kazakhstan	2,030	1,400	6,100	495	348	1,580	--	--	--	43,100	29,500	51,200	45,600	31,300	58,900
Netherlands	22	16	92	--	--	--	--	--	--	--	--	--	22	16	92
Russia	23,900	16,400	71,100	249	175	708	3,160	1,700	1,690	15,900	10,100	15,900	43,200	28,400	89,400
South Africa	3,630	2,160	7,840	1,210	657	1,640	--	--	--	136,000	67,000	96,100	141,000	69,800	106,000 [r]
Sweden	115	75	574	--	--	--	--	--	--	317	210	791	433	285	1,370
Turkey	180	126	390	--	--	--	--	--	--	--	--	--	180	126	390
Total	36,600	24,800	111,000	2,110	1,280	4,290	3,180	1,720	1,720	198,000	109,000	167,000	240,000	137,000	285,000
2010:															
Albania	1,370	903	3,280	--	--	--	--	--	--	11,600	7,610	16,700	13,000	8,510	20,000
Belgium	500	351	2,020	--	--	--	20	15	79	--	--	--	520	367	2,100
Brazil	--	--	--	--	--	--	--	--	--	19	12	49	19	12	49
China	2,570	1,520	6,860	140	92	371	40	40	123	960	667	1,770	3,710	2,320	9,130
Finland	--	--	--	--	--	--	--	--	--	429	217	415	429	217	415
France	--	--	--	--	--	--	--	--	--	(3)	(3)	3	(3)	(3)	3
Germany	5,240	3,670	21,800	--	--	--	--	--	--	50	35	176	5,290	3,710	21,900
India	--	--	--	--	--	--	475	292	611	13,300	8,170	18,900	13,800	8,470	19,500
Japan	2,050	1,420	9,010	--	--	--	--	--	--	--	--	--	2,050	1,420	9,010
Kazakhstan	2,920	1,860	8,150	--	--	--	--	--	--	112,000	77,900	194,000	115,000	79,700	203,000
Latvia	--	--	--	--	--	--	--	--	--	200	140	375	200	140	375
Netherlands	81	60	298	--	--	--	--	--	--	--	--	--	81	60	298
Romania	--	--	--	--	--	--	--	--	--	3,030	1,710	3,410	3,030	1,710	3,410
Russia	32,400	22,600	98,500	1,050	720	2,840	636	350	473	33,500	21,300	53,300	67,600	45,000	155,000
Slovenia	--	--	--	--	--	--	--	--	--	100	62	139	100	62	139
South Africa	1,000	608	3,080	1,180	640	2,110	--	--	--	243,000	121,000	250,000	245,000	122,000	255,000
Sweden	23	16	138	--	--	--	--	--	--	8,050	5,190	14,200	8,070	5,210	14,300
Switzerland	--	--	--	--	--	--	--	--	--	96	67	124	96	67	124
Turkey	1,700	1,210	5,450	--	--	--	--	--	--	11,000	7,280	20,000	12,700	8,480	25,400

See footnotes at end of table.

TABLE 5—Continued

U.S. IMPORTS FOR CONSUMPTION OF FERROCHROMIUM, BY COUNTRY[1]

Country	Not more than 0.5% carbon (HTS[2] code 7202.49.5090)			More than 0.5% carbon, but not more than 3% carbon (HTS[2] code 7202.49.5010)			More than 3% carbon, but not more than 4% carbon (HTS[2] code 7202.49.1000)			More than 4% carbon (HTS[2] code 7202.41.0000)			Total all grades		
	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)	Gross weight (metric tons)	Cr content (metric tons)	Value (thousands)
2010—Continued:															
United Kingdom	--	--	--	--	--	--	--	--	--	24	19	$68	24	19	$68
Zimbabwe	--	--	--	--	--	--	--	--	--	16,500	9,550	23,400	16,500	9,550	23,400
Total	49,900	34,300	$159,000	2,370	1,450	$5,320	1,170	697	$1,290	454,000	261,000	597,000	507,000	297,000	763,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE[1]

		2009		2010		
HTS[2] code	Type	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Sources in 2010 (Quantity in metric tons, value in thousands)
	Chromite ore:					
2610.00.0020	Not more than 40% Cr_2O_3:					
	Gross weight	10,300	$3,540	--	--	
	Cr_2O_3 content	2,560	XX	--	XX	
2610.00.0040	More than 40%, but less than 46% Cr_2O_3:					
	Gross weight	859	533	65,400	$11,000	South Africa (all).
	Cr_2O_3 content	394	XX	29,900	XX	
2610.00.0060	46% or more Cr_2O_3:					
	Gross weight	66,100	13,400	73,700	18,600	South Africa (73,700, $18,600); Russia (2, $29).
	Cr_2O_3 content	30,600	XX	34,300	XX	
	Total chromite ore:					
	Gross weight	77,200	17,500	139,000	29,600	
	Cr_2O_3 content	33,600	XX	64,100	XX	
	Chromium ferroalloys:					
	Ferrochromium:					
7202.49.5090	Not more than 0.5% carbon:					
	Gross weight	36,600	111,000	49,900	159,000	Russia (32,400, $98,500); Germany (5,240, $21,800); Kazakhstan (2,920, $8,150); China (2,570, $6,860); Japan (2,050, $9,010); Turkey (1,700, $5,450); Albania (1,370, $3,280); South Africa (1,000, $3,080); Belgium (500, $2,020); Netherlands (81, $298); Sweden (23, $138).
	Cr content	24,800	XX	34,300	XX	
7202.49.5010	More than 0.5%, but less than 3% carbon:					
	Gross weight	2,110	4,290	2,370	5,320	South Africa (1,180, $2,110); Russia (1,050, $2,840); China (140, $371).
	Cr content	1,280	XX	1,450	XX	
7202.49.1000	More than 3%, but less than 4% carbon:					
	Gross weight	3,180	1,720	1,170	1,290	Russia (636, $473); India (475, $611); China (40, $123); Belgium (20, $79).
	Cr content	1,720	XX	697	XX	
7202.41.0000	More than 4% carbon:					
	Gross weight	198,000	167,000	454,000	597,000	South Africa (243,000, $250,000); Kazakhstan (112,000, $194,000); Russia (33,500, $53,300); Zimbabwe (16,500, $23,400); India (13,300, $18,900); Albania (11,600, $16,700); Turkey (11,000, $20,000); Sweden (8,050, $14,200); Romania (3,030, $3,410); China (960, $1,770); Finland (429, $415); Latvia (200, $375); Slovenia (100, $139); Switzerland (96, $124); Germany (50, $176); United Kingdom (24, $68); Brazil (19, $49).
	Cr content	109,000	XX	261,000	XX	

See footnotes at end of table.

TABLE 6—Continued

U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE[1]

HTS[2] code	Type	2009 Quantity (metric tons)	2009 Value[3] (thousands)	2010 Quantity (metric tons)	2010 Value[3] (thousands)	Sources in 2010 (Quantity in metric tons, value in thousands)
7202.50.0000	Ferrochromium-silicon:					
	Gross weight	7,560	$9,140	17,000	$28,200	Kazakhstan (all).
	Cr content	3,120	XX	7,210	XX	
	Total chromium ferroalloys:					
	Gross weight	248,000	294,000	524,000	791,000	
	Cr content	140,000	XX	305,000	XX	
	Chromium metal, gross weight:					
8112.21.1000	Unwrought chromium powders	635	6,410	1,860	22,800	China (978, $13,000); United Kingdom (535, $5,930); Russia (113, $1,440); France (105, $1,380); Spain (104, $579); Japan (15, $179); Germany (9, $219); Romania (2, $75).
8112.22.0000	Waste and scrap	107	797	544	2,260	Mexico (515, $1,730); Germany (17, $263); Singapore (12, $266); Japan (1, $4).
8112.29.0000	Other than waste and scrap	6,830	67,700	10,600	122,000	Russia (3,570, $38,700); France (2,480, $31,800); United Kingdom (2,430, $28,800); China (2,060, $21,000); Netherlands (41, $338); Germany (31, $1,070); Japan (11, $330); Kazakhstan (5, $358).
	Total chromium metal	7,570	74,900	13,000	148,000	
	Chemicals, gross weight:					
	Chromium oxides and hydroxides:					
2819.10.0000	Chromium trioxide	6,240	18,400	5,050	14,100	Turkey (3,090, $7,930); Kazakhstan (1,100, $2,870); South Africa (356, $977); China (309, $1,380); Canada (116, $479); Japan (36, $242); Germany (27, $76); Colombia (14, $77); Spain (4, $27); France (2, $12); Mexico (1, $3).
2819.90.0000	Other	2,850	9,560	3,200	13,800	China (1,950, $9,370); Canada (706, $796); Germany (295, $2,180); Kazakhstan (95, $458); Colombia (90, $586); India (20, $66); France (19, $114); Spain (11, $56); United Kingdom (6, $37); Republic of Korea (4, $125); Japan (1, $25); Finland (1, $16).
	Total oxides	9,100	28,000	8,240	27,900	
2833.29.4000	Sulfates of chromium	71	88	325	351	Turkey (all).
	Salts of oxometallic or peroxometallic acids:					
2841.90.4500	Chromates of lead and zinc	32	101	168	701	China (81, $316); Japan (57, $216); Republic of Korea (21, $101); France (9, $51); Brazil (1, $12).
2841.30.0000	Sodium dichromate	15,000	17,300	150	438	China (101, $239); Colombia (44, $191); Italy (4, $8).
	Other chromates and dichromates;					
	Peroxochromates:					
2841.50.1000	Potassium dichromate	3	10	12	59	Colombia (9, $31); India (2, $13); Japan (1, $11).
2841.50.9100	Other	239	711	439	1,530	Austria (321, $1,160); Brazil (38, $107); Canada (37, $93); Colombia (17, $57); Germany (16, $30); France (5, $49); Spain (3, $13); China (2, $15).
	Total salts	15,300	18,100	769	2,730	

See footnotes at end of table.

TABLE 6—Continued
U.S. IMPORTS FOR CONSUMPTION OF CHROMIUM MATERIALS, BY TYPE[1]

		2009		2010		
HTS[2] code	Type	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Sources in 2010 (Quantity in metric tons, value in thousands)
2849.90.2000	Chromium carbide	165	$3,060	242	$4,370	China (91, $1,900); United Kingdom (56, $635); Canada (45, $846); Japan (37, $466); Germany (11, $416); Russia (1, $10); Austria (1, $103).
	Total chromium chemicals	24,600	49,300	9,580	35,400	
	Pigments and preparations based on chromium, gross weight:					
3206.20.0010	Chrome yellow	1,000	4,670	1,550	7,030	China (709, $2,400); Canada (579, $3,600); Colombia (130, $434); Mexico (88, $365); Germany (37, $216); France (5, $11).
3206.20.0020	Molybdenum orange	269	2,170	349	2,730	Canada (247, $2,220); Mexico (50, $293); United Kingdom (30, $78); Colombia (10, $49); Germany (6, $29); China (3, $18); Japan (2, $12); Italy (2, $18).
3206.20.0030	Zinc yellow	168	464	92	282	China (70, $198); United Kingdom (12, $31); Mexico (6, $24); Italy (4, $25).
3206.20.0050	Other	254	1,350	292	1,540	China (120, $527); France (100, $391); Germany (29, $215); Poland (19, $126); Japan (14, $107); Canada (5, $40); Netherlands (2, $17); United Kingdom (1, $96); India (1, $14).
	Total pigments	1,700	8,650	2,280	11,600	

XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Customs import value generally represents a value in the foreign country and therefore excludes U.S. import duties, freight, insurance, and other charges incurred in bringing the merchandise into the United States.

TABLE 7
WORLD PRODUCTION CAPACITY OF CHROMITE ORE, FERROCHROMIUM, CHROMIUM METAL, CHROMIUM CHEMICALS, AND STAINLESS STEEL IN 2010[e, 1]

(Thousand metric tons of contained chromium)

Country	Production capacity				
	Ore	Ferrochromium	Metal	Chemicals	Stainless steel
Afghanistan	2	--	--	--	--
Albania	87	11	--	--	--
Argentina	--	--	--	13	--
Australia	78	--	--	--	--
Austria	--	--	--	--	10
Belgium	--	--	--	--	259
Brazil	193	123	--	--	84
China	60	1,260	6	70	1,960
Czech Republic	--	--	--	--	3
Finland	185	153	--	--	222
France	--	--	7	--	92
Germany	--	17	1	--	293
Greece	(2)	--	--	--	--
India	1,170	567	(2)	31	330
Iran	81	5	--	2	--
Italy	--	--	--	--	310
Japan	--	9	1	17	688
Kazakhstan	1,150	719	2	37	--
Korea, Republic of	--	--	--	--	389
Kosovo	1	--	--	--	--
Madagascar	40	--	--	--	--
Oman	259	--	--	--	--
Pakistan	97	--	--	3	--
Philippines	14	--	--	--	--
Poland	--	--	--	--	1
Russia	291	372	16	31	31
Slovenia	--	--	--	--	18
South Africa	3,270	1,880	--	23	124
Spain	--	--	--	--	212
Sudan	17	--	--	--	--
Sweden	--	71	--	--	116
Taiwan	--	--	--	--	292
Turkey	568	42	--	17	--
Ukraine	--	--	--	--	21
United Arab Emirates	10	--	--	--	--
United Kingdom	--	--	7	--	66
United States	--	--	--	38	420
Vietnam	31	--	--	--	--
Zimbabwe	215	128	--	--	--
Total	7,820	5,360	40	282	5,940

[e]Estimated. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

TABLE 8

CHROMITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	2006	2007	2008	2009	2010
Afghanistan[4]	7,273	6,491	6,491	6,000 [e]	6,000 [e]
Albania[5]	212,581	199,771	207,104	288,759 [r]	289,687
Australia	258,087	253,400	224,809	119,314	--
Brazil[6]	562,739	627,772	664,347 [r]	365,210 [r]	370,000 [p]
China[e]	200,000	200,000	200,000	200,000	200,000
Cuba	27,900	-- [r]	-- [r]	-- [r]	--
Finland	548,713	556,100	613,543	246,817	245,000
Greece[4]	1,500	1,400	1,400 [e]	1,400 [e]	1,400 [e]
India	3,600,400	3,320,000	3,900,000	3,760,000	3,800,000
Iran	244,603	185,760	268,586 [r]	255,129	250,000 [e]
Kazakhstan	3,366,078	3,687,200	3,552,000 [r]	3,544,000 [r]	3,829,000
Madagascar	132,335	122,260	84,000	60,000 [e]	105,000
Oman	70,500	407,822	859,748	636,482	801,856
Pakistan	199,000	323,100	320,000 [e]	90,000 [r]	257,000
Philippines	46,728	31,592	15,268	16,000 [r, e]	16,000 [e]
Russia	966,065	776,681	913,000	416,194	400,000 [e]
South Africa	7,418,326	9,646,958	9,682,640	7,560,938 [r]	10,871,095
Sudan	28,772	15,476	27,094 [r]	14,087 [r]	56,823
Turkey	1,059,901	1,678,932	1,885,712	1,573,993 [r]	1,700,000 [e]
United Arab Emirates	--	19,000	34,350	23,770	25,000
Vietnam	73,037	103,830	55,880	37,105	37,000 [e]
Zimbabwe	712,908	663,593	484,482	279,360	425,353
Total	19,700,000	22,800,000 [r]	24,000,000 [r]	19,500,000 [r]	23,700,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 22, 2011.

[3] Figures for all countries represent marketable output unless otherwise noted.

[4] Gross weight estimated assuming an average grade of 44% chromic oxide (Cr_2O_3).

[5] Ore grade was 18% to 42% Cr_2O_3.

[6] Average chromic oxide (Cr_2O_3) content was as follows: 2006—40.6%; 2007—40.3%; 2008—42.5%; 2009—40.0%; and 2010—40.0% (estimated).

TABLE 9
FERROCHROMIUM: WORLD PRODUCTION, BY COUNTRY[1,2]

(Metric tons, gross weight)

Country	2006	2007	2008	2009	2010
Albania	17,040	--	11,916	7,556	8,000 [e]
Brazil[3]	166,577	195,890	194,324 [r]	131,048 [r]	170,000 [p]
China[e]	1,000,000	1,300,000	1,500,000	1,810,000 [r]	2,000,000
Finland	243,350	241,760	233,550	123,310	125,000
Germany	26,710	22,030	26,960	13,667	20,000 [e]
India[4]	634,200	820,000	750,000	873,385 [r]	850,000
Iran[e]	7,000	8,000	8,000	8,000	8,000
Japan[3]	13,056	12,016	13,888	7,698 [r]	16,208
Kazakhstan	1,190,673 [r]	1,307,536	1,220,315	1,173,286 [r]	1,250,000 [e]
Romania	--	--	W	W	W
Russia[e]	600,000	570,000	490,000	378,000 [5]	414,000
Slovakia	19	--	--	--	--
South Africa[6]	3,030,000	3,551,983 [r]	3,268,659 [r]	2,346,131 [r]	3,607,132
Sweden	136,374	124,403	117,053	31,345	36,000
Turkey	67,975	69,730	79,840 [r]	41,028	60,000 [e]
United States[7]	W	W	W	W	W
Zimbabwe	200,673	187,327 [r]	145,430 [r]	72,223 [r]	150,000
Total	7,330,000 [r]	8,410,000 [r]	8,060,000	7,020,000 [r]	8,710,000

[e] Estimated. [p] Preliminary. [r] Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 22, 2011.

[3] Includes high- and low-carbon ferrochromium.

[4] Reported on a fiscal year basis, which is from April 1 to March 31. Includes ferrochrome and charge chrome.

[5] Reported figure.

[6] Includes high- and low-carbon ferrochromium and ferrochromium-silicon.

[7] Includes chromium metal, high- and low-carbon ferrochromium, ferrochromium-silicon, and other chromium materials.

CLAY AND SHALE

By Robert L. Virta

Domestic survey data and tables were prepared by Robin C. Kaiser, statistical assistant, and the world production tables were prepared by Lisa D. Miller, international data coordinator.

The amount of clay sold or used by domestic producers in 2010 increased by 4% to 25.4 million metric tons (Mt) valued at $1.46 billion compared with 24.5 Mt valued at $1.33 billion in 2009 (table 1). Common clay and shale accounted for 47% of the tonnage, and kaolin accounted for 54% of the value (tables 1, 5, and 8). In 2010, exports increased by 14% to 4.36 Mt valued at $862 million compared with 3.83 Mt valued at $702 million in 2009. Imports of clays were 284,000 metric tons (t) valued at $92 million in 2010 compared with 325,000 t valued at $104 million in 2009 (table 1). World production of bentonite was 10.7 Mt, production of fuller's earth was 3.36 Mt, and production of kaolin was 33.2 Mt.

About 170 companies mined clay and shale in the United States in 2010. The 20 leading companies, many with multiple operations, accounted for 55% of the tonnage and 74% of the value for all types of clay produced and sold or used. Clay production was reported in all States except Alaska, Delaware, Hawaii, Idaho, New Hampshire, Rhode Island, Vermont, and Wisconsin (table 2). Companies that mined clay for construction fill and landfill caps and did not operate mills or plants were not included in the U.S. Geological Survey (USGS) canvass of the clay and shale industry. These companies operated in most, if not all, States.

The 10 leading producer States were, in decreasing order of tonnage, Georgia, Wyoming, Texas, Alabama, Missouri, North Carolina, Ohio, Tennessee, Virginia, and Mississippi. The 10 leading producer companies were, in alphabetical order, American Colloid Co. (bentonite); BASF SE (bentonite, fuller's earth, and kaolin); Bentonite Performance Minerals LLC (bentonite); Black Hills Bentonite Co. (bentonite); General Shale Products Corp. (common clay and shale); Imerys SA (ball clay and kaolin); Nestle S.A. (fuller's earth); Oil-Dri Corp. of America (fuller's earth); Texas Industries Inc. (common clay and shale); and Unimin Corp. (ball clay and kaolin).

Most clay mining in the United States was by open pit methods; less than 1% of U.S. clay output was from underground mines. Most underground production was in Ohio, where the clays were mainly underclays associated with coal.

Domestic production data for clays were developed by the USGS from a voluntary survey of U.S. operations. Responses to the survey and company production data available from other sources accounted for approximately 50% of the total clay and shale tonnage sold or used quantity listed in table 1. Production data for the nonrespondents were estimated from preliminary survey data or reported prior-year production levels adjusted by trends in the industry, employment hours, and other guidelines.

Ball clay

Production.—In 2010, four companies mined ball clay in four States. Production of domestic ball clay increased by 10% to 912,000 t valued at $41.3 million compared with 831,000 t valued at $37.7 million in 2009 (table 3). Operations in Tennessee supplied 63% of the production, followed by, in descending order of tonnage, Texas, Mississippi, and Kentucky. One producer reported a small amount of production in Indiana, but this probably was fire clay rather than ball clay.

Consumption.—Consumption of ball clay increased in 2010. The principal domestic markets were, in decreasing order by tonnage, ceramic floor and wall tile and sanitaryware. Ball clay also was sold to manufacture bricks, fiberglass, refractory products, and other types of ceramics and as fillers, extenders, and binders (table 3). Sales for fiberglass and some filler and extender applications were likely to have been kaolin mined or purchased by the ball clay producers.

Although the reported tonnage of ball clay under the floor and wall tile category declined in 2010, most of the difference between 2010 and 2009 probably can be accounted for under the miscellaneous category. With housing starts in the United States increasing slightly in 2010 compared with those of 2009, sales of ball clay for floor and wall tile were likely to have increased slightly to about 320,000 t.

Domestic sales of ball clay can be affected by imports of products such as ceramics and sanitaryware because they compete with ball clay-based ceramic products manufactured in the United States. The U.S. International Trade Commission (undated) reported that imports of ceramic tile under Harmonized Tariff Schedule (HTS) of the United States Codes 6907.10.00, 6908.10.10, 6908.10.20, and 6908.10.50 increased in quantity to 7.10 million square meters valued at $68.4 million in 2010 from 6.95 million square meters valued at $68.6 million in 2009 but was still much less than the 10.8 million square meters imported in 2008. Mexico, China, Italy, Brazil, and Spain were the five leading sources of tile imports, with 24%, 17%, 12%, 9%, and 6% of the import volume, respectively. Imports of sanitaryware under the 4-digit HTS Code 6910 increased to 24.4 million units in 2010 from 21.8 million units in 2009. This was still considerably less than 34 million units imported in 2008. China accounted for 11.6 million units or 48% of the U.S. sanitaryware imports in 2010, and Mexico accounted for 9.06 million units or 37% of the imports.

Imerys, the leading ball clay producer in the United States, had only a small increase in global sales of minerals for ceramics applications in 2010. This was attributed to low growth in construction markets in developed countries (Imerys SA, 2011, p. 7).

Prices.—The average unit value for ball clay reported by domestic producers was $45.26 per metric ton. The average value for exported ball clay was $67.40 per ton. The average value for imported ball clay was $138.00 per ton.

Trade.—Ball clay exports were 45,000 t valued at $3.03 million in 2010 compared with 35,000 t valued at $2.43 million in 2009, according to the U.S. Census Bureau (table 14). Producers reported exports of 191,000 t (table 3). Most of the difference in exports reported by producers and the U.S. Census Bureau involves shipments to Mexico, whose trade statistics suggest that their kaolin import data included most of the imports of ball clay from the United States under the Harmonized Tariff Standard code for kaolin and other kaolinic clays. The water weight of slurry shipments (about 30% to 35% of the shipment weight) also may account for a portion of the extra tonnage reported by producers (table 15).

Outlook.—The U.S. economy began to recover from the 2008–09 recession but commercial and residential construction activity continued to remain low. Overall construction spending for residential and commercial buildings remained stagnant, and other private residential housing statistics, such as housing completions, units authorized but not yet started, and units under construction, suggest that residential construction still is suffering from the effects of the recession with only a very slow recovery (U.S. Census Bureau, 2011a, d, e, g, undated). Mortgage foreclosures, tight credit, proposed new lending laws, and continued uncertainty in U.S. debt issues contributed to the slow recovery of the commercial and residential construction industry.

Because most sales of ball clay were for the manufacture of floor and wall tile, sanitaryware, and other construction-related ceramics, future growth in ball clay sales are likely to be slow for the next 2 years. Despite the slow recovery of the U.S. economy, it still may be sufficient for ball clay production and sales to increase slightly in 2011 compared with those of 2010. Growth in global construction markets also is likely to be slow as many world economies, particularly those in Europe, continue to struggle to recover from the recession. The exceptions are construction markets in Asia and some markets in South America, which were less affected by the 2008–09 global recession. Ball clay exports, mainly to Canadian and Central American ceramics producers, may increase slightly in 2011.

Bentonite

Production.—In 2010, 20 companies produced bentonite in 11 States. About 4.63 Mt valued at $261 million was sold or used in 2010, 27% more than the 3.65 Mt valued at $207 million of bentonite sold or used in 2009 (table 4). Production of nonswelling bentonite increased by 6% to 123,000 t valued at $9.32 million in 2010 from 116,000 t valued at $8.14 million in 2009. Alabama led in the production of nonswelling bentonite, followed by, in descending order of tonnage, Mississippi, Arizona, California, and Nevada.

Production of swelling bentonite was 4.51 Mt valued at $252 million in 2010, an increase of 28% from 3.53 Mt valued at $198 million in 2009. Wyoming led in the production of swelling bentonite, followed by Utah, Montana, Texas, California, Oregon, Nevada, and Colorado.

Wyo-Ben, Inc. began operating its bentonite plant in Lucerne, WY, after it was refurbished in 2009. The plant had a production capacity of 500,000 metric tons per year (t/yr) and served such markets as cat litter, drilling mud, and foundry sand. The plant also had the capability to produce bentonite for iron ore pelletizing (Russell, 2010).

Black Hills Bentonite, LLC submitted plans to the U.S. Bureau of Land Management (BLM) to mine bentonite near Ten Sleep, WY. The company planned to extract about 72,900 t of bentonite during the 10-year life of the mine. A mine plan and environmental assessment were available from the BLM for review (U.S. Bureau of Land Management, 2009; 2010).

Consumption.—In 2010, domestic sales and use of bentonite increased from that of 2009. Reported domestic sales of bentonite were 1.02 Mt for drilling mud (all swelling bentonite), 423,000 t for foundry sand bond (more than 99% was swelling bentonite), 595,000 t for pelletizing iron ore (all swelling bentonite), and 967,000 t for pet waste absorbent (all swelling bentonite). Bentonite also was sold for civil engineering and sealing; fillers, extenders, and binders; waterproofing and sealing; and a variety of other applications (table 4).

Domestic sales of bentonite increased for pet litter, drilling mud, pelletizing iron ore, waterproofing and sealing, and miscellaneous uses. Domestic sales of bentonite for drilling mud use increased by 74%, and export sales increased by 52% (table 4). Drilling activity increased domestically and overseas in 2010 compared with 2009 (Baker Hughes Inc., undated). Sales reported in table 4, however, appeared to be unusually high for 2010, and it is likely that some of the sales were improperly categorized by respondents and that sales increased by 20% to 30% to about 750,000 t. Sales of bentonite for iron ore pelletizing increased by 34% in 2010. This corresponds with a reported 87% increase in iron ore production and a 65% increase in iron ore shipments in 2010 (Jorgenson, 2011b). Reported domestic sales for foundry sand bond applications decreased by 5% domestically, and sales for export decreased by 37%. This was contrary to a report on market conditions from a major supplier of bentonite, which indicated that sales for metal casting applications increased significantly in 2010 (AMCOL International Corp., 2011, p. 30). Some of the tonnage attributed to drilling mud and the "Miscellaneous" (domestic) category likely should have been attributed to foundry sand bond sales, with domestic sales of bentonite for foundry sand bond estimated to be 520,000 to 540,000 t, and export sales estimated to be 225,000 to 250,000 t.

The leading markets shown in table 4 are representative of those of swelling bentonite, which accounted for 97% of total bentonite sales. The leading uses of nonswelling bentonite were in foundry sand and water treatment and filtering.

For smaller markets, swelling bentonite accounted for more than 95% of the bentonite sold for adhesives; animal feed; clarifying and decolorizing animal, mineral, and vegetable oils and greases; cosmetics, medical, and pharmaceutical; fertilizers; miscellaneous ceramics; miscellaneous fillers and extenders; oil and grease absorbents; paint; and plastics. Swelling bentonite accounted for less than 50% of sales for water treatment and filtering. Nonswelling bentonite accounted for most sales for chemical manufacturing and fertilizer and pesticide carriers.

In 2010, American Colloid Co. reported sales of 1.57 Mt of sodium bentonite and 81,700 t of calcium bentonite from mines in the United States compared with 1.25 Mt of sodium bentonite and 60,900 t of calcium bentonite in 2009. The company reported a 46% increase in sales revenue for metal casting applications, its leading revenue market. Sales revenue for its other markets, with the exception of pet litter, also increased; sales revenue for pet litter declined 7% (AMCOL International, 2011, p. 11, 30).

Rockwood Holdings, Inc. (the parent company of Southern Clay Products, Inc.) reported increased sales in most clay-additive markets, particularly for oilfield applications. Pricing for clay additives also increased in 2010 (Rockwood Holdings, Inc., 2011, p. 38, 44).

Prices.—The average unit value reported by domestic producers for nonswelling bentonite was $75.79 per metric ton. The average value for swelling bentonite was $55.88 per ton. The average value for all bentonite was $56.40 per ton. The average value of exported bentonite was $149.85 per ton. The average value of imported bentonite was $292.06 per ton.

The price of bentonite that was sold in bulk, crude form in railcars for iron ore pelletizing from the mill in Wyoming was $48 to $55 per ton; foundry-grade that was bagged and shipped in railcars was $90 to $115 per ton; and American Petroleum Institute (API)-grade bentonite that was bagged and shipped in railcars was $70 to $100 per ton. Crushed, dried, loose in bulk bentonite from India was $45 to $50 per ton for pet litter grade. Crude and dried bentonite, sold in bulk, free on board, European port, was $56 to $80 per ton for foundry grade (Industrial Minerals, 2010).

The average annual producer price index (PPI) for bentonite under North American Industry Classification System (NAICS) code 212325C was 157.8 in 2010 (1984=100) compared with 155.3 in 2009. The PPI increased during the year from 154.7 in February to 161.8 in December. The PPI measured the average change in the selling prices charged by domestic producers of bentonite over time (U.S. Bureau of Labor Statistics, undated).

Trade.—Bentonite exports increased to 953,000 t valued at $143 million in 2010 from 709 Mt valued at $100 million in 2009 (table 14). Canada and Japan accounted for the largest share of the increase in exports. Most of the increase was related to the improving economies with increased demand for bentonite by the iron ore, foundry, and oil drilling industries. Changes in trade with other countries were relatively minor. Domestic bentonite producers reported exports of 817,000 t (table 4). Much of the discrepancy between data reported by producers and the U.S. Census Bureau data probably resulted from producers including a portion of the exports destined for Canadian and Mexican markets under domestic sales. In addition, some bentonite is packaged domestically and then exported as a finished product, such as cat litter. Sales through U.S. mineral brokers, where producers do not know if the bentonite is used domestically or exported, could also explain part of the discrepancy.

Bentonite imports consisted mainly of untreated bentonite clay and chemically or artificially activated materials. Imports of untreated bentonite were 16,000 t valued at $4.67 million. Imports of artificially activated material were 19,000 t valued at $25.8 million (table 15).

Outlook.—The bentonite industry rebounded in 2010 after a major decline in sales in 2009 because of the global economic recession. Sales in 2010 were nearing the levels reached just prior to the recession. Demand for bentonite increased in most markets as global economies began to recover. Overall bentonite sales may increase by 6% to 9% in 2011 because of growth in a few of the major markets for bentonite.

Growth in absorbent markets, particularly pet waste absorbents, slowed significantly in recent years. Overall sales for pet waste absorbents declined slightly during the past 2 years because of reduced consumer spending during the recession. With little significant change in consumer spending anticipated in 2011, pet litter markets may remain unchanged. Sales of bentonite for oil absorbent applications were likely to increase by 3% to 6% in 2011 compared with those of 2010 because of increased U.S. industrial output in the manufacturing sector (Board of Governors of the Federal Reserve System, 2011).

Sales of bentonite for drilling mud applications may increase slightly in 2011 compared with those of 2010 because of increased drilling activity in 2011. Sales of bentonite also were tied to the iron and steel industries because of its use for pelletizing iron ore and as a foundry sand bond. Production of iron ore increased in 2010 but declined slightly in the first 5 months of 2011 (Jorgenson, 2011a). Demand for iron ore, however, is likely to increase in 2011 as global economies recover, so sales of bentonite for pelletizing iron ore may increase slightly in 2011.

The world foundry industry also began to recover from market losses in 2008 and 2009 (Roberts, 2010: S&B Industrial Minerals S.A., 2011, p. 8). Manufacturing of durable goods increased in 2011 compared with 2010 (Board of Governors of the Federal Reserve System, 2011). Consequently, sales of bentonite for foundry sand bond applications may increase slightly in 2011.

Sales of bentonite for civil engineering applications, such as waterproofing and sealing and landfill caps and liners, were affected by reduced construction activity during the recession. In the United States in 2010, construction activity continued to be relatively low compared with that of 2008. Sales of bentonite for waterproofing and sealing are likely to increase slightly in 2011. Other smaller markets for bentonite may increase slightly in 2011 as the U.S. economy slowly improves.

Common Clay and Shale

Production.—In 2010, 133 companies produced common clay and shale for manufacturing products in 38 States and Puerto Rico. Companies that mined clay for construction fill and landfill caps and did not operate mills or plants were not included in the USGS canvass of the clay and shale industry. These companies operated in most, if not all, States.

Domestic sales or use of common clay and shale decreased by 3% to 12.1 Mt valued at $148 million in 2010 compared with 12.5 Mt valued at $156 million in 2009 (table 5). The 10 leading producing States were, in descending order of tonnage, Texas, Alabama, North Carolina, Ohio, Georgia, New York, Oklahoma, Arkansas, Virginia, and Missouri. These 10 States accounted for 66% of U.S. common clay and shale production. Sales declined in many States owing to low residential and commercial building activity in 2010.

Boral USA purchased the remaining 50% interest in MonierLifetile LLC, a division of Monier Group of Germany. MonierLifetile was based in Irving, CA, and produced clay and concrete roofing tile for residential and commercial use. Boral combined its roofing division with that of MonierLifetile under a new Boral Roofing division. The purchase gave Boral better access to the U.S. roofing market with 15 tile plants throughout the United States (Boral USA, 2010).

Mid America Brick received $21.9 million in financing to open a former refractory brick plant to manufacture face brick. The former plant was owned by A.P. Green Inc. and had been idled since 2002. The plant was expected to produce 60 million bricks per year at full capacity (Advantage Capital Partners, 2010; Mid America Brick, 2010).

Consumption.—Brick manufacture remained the leading market for common clay and shale, followed by, in descending order of tonnage, lightweight aggregate and portland cement. These three markets accounted for 91% of sales in 2010. Lightweight aggregate sales were subdivided into concrete block (1.34 Mt), structural concrete (701,000 t), highway surfacing (561,000 t), and miscellaneous lightweight aggregates (266,000 t). Other markets included civil engineering, ceramic floor and wall tile, miscellaneous ceramics, heavy-clay (nonbrick) products, and refractory products (table 5).

Production of brick was 3.61 billion bricks in 2010 compared with 3.28 billion bricks in 2009, and brick shipments were 3.50 billion bricks in 2010 compared with 3.59 billion bricks in 2009. Production of clay floor and wall tile, which is an important market for common clay and shale, was 66.1 million square meters in 2010 compared with 55.4 million square meters in 2009. Shipments were 60.3 million square meters in 2010 compared with 53.1 million square meters in 2009. Production of clay pipe and fittings was 43,100 t in 2010 compared with 45,000 t in 2009, and shipments were 48,000 t in 2010 compared with 45,500 t in 2009 (U.S. Census Bureau, 2011b, undated). The increase in shipments of tile and clay pipe and fittings corresponded with a slight increase in housing starts (588,000 units in 2010 compared with 554,000 units in 2009) although commercial construction, based on the value of construction put in place, appeared to have declined ($563 trillion in 2010 compared with $654 trillion in 2009) (U.S. Census Bureau, 2011a, undated).

Prices.—The unit average value for all common clay and shale produced in the United States was $12.25 per metric ton. The value of clay and shale used to produce lightweight aggregate was estimated to be $25.28 per ton in 2010. Average prices for lightweight aggregate produced from clay and shale ranged from $30 to $80 per ton for most applications. Unit values for common clay and shale should be used with caution because most producers do not sell their clay, but use it directly to manufacture products.

The annual average PPI for common (miscellaneous) clay and shale under NAICS code 212325B was 176.6 in 2010 (1984=100) compared with 171.7 in 2009. The PPI increased to 179.9 in July and declined to 177.9 in December. The PPI measured the average change in the selling prices charged by domestic producers of common (miscellaneous) clay and shale over time (U.S. Bureau of Labor Statistics, undated).

Outlook.—Common clay and shale continued to be affected by the sluggish U.S. economy in 2010. Although housing starts increased slightly through mid-2011, overall construction spending for residential and commercial buildings remained stagnant. Other private residential housing statistics, such as housing completions and units under construction, also suggest that residential construction still was feeling the effects of the recession (U.S. Census Bureau, 2011a, d, e, g, undated). Mortgage foreclosures, tight credit, proposed new lending laws, and continued uncertainty in U.S. debt issues contributed to the slow recovery of the commercial and residential construction industry. These issues are likely to constrain the sales of common clay, with only slight growth expected in 2011.

Fire clay

Production.—Fire clay producers were mostly refractory product manufacturers that used the clays in firebrick and various heavy-clay products. In 2010, six firms mined fire clay in four States. Fire clay mined by domestic producers decreased by 32% to 216,000 t valued at $6.12 million from 320,000 t valued at $12 million in 2009 (table 6). Missouri was the leading producing State, followed by, in descending order of tonnage, Washington, Texas, and Ohio. The decrease in production took place because several common clay producers that occasionally mine fire clay indicated that they did not do so in 2010.

Consumption.—Consumption of fire clay decreased in 2010. Leading markets for fire clay were, in descending order of tonnage, portland cement, refractory calcines and grogs, ceramic floor and wall tile, firebrick, common brick, miscellaneous ceramics, and roofing granules (table 6).

Fire clay products sold included grogs and calcines; high-alumina brick and specialties; ramming and gunning mixes; refractory products, such as firebrick and block; mixes and mortars; and saggers. Fire clays also were used to produce such items as brick and pottery. Sales for these nonrefractory products decreased because several common clay and shale producers indicated that they did not mine fire clay in 2010.

The U.S. Census Bureau (2011f) reported that the value of U.S. manufacturers' shipments of clay refractory products (based primarily on fire clay and kaolin) was $818 million in 2010 compared with $638 million in 2009. The value of U.S. apparent consumption (manufacturers' shipments plus imports minus exports) of all clay refractory products was $774 million in 2010 versus $596 million in 2009. In 2010, shipments of fire clay, high-alumina, and insulating brick shapes in 9-inch equivalents, were 312,000 t compared with 258,000 t in 2009. Shipments of castables, gunning mixes, and unshaped clay refractory bonding mortars were 386,000 t in 2010 compared with 321,000 t in 2009. Shipments of clay and high alumina refractory materials for reprocessing and direct sales were withheld by the Census Bureau in 2010 to avoid disclosing company proprietary data.

Prices.—In 2010, the average unit value for fire clay reported by domestic producers was $28.31 per metric ton, a decrease from $37.48 in 2009. The decrease in value in 2010 resulted from lower values reported by two fire clay producers. The average value of exported fire clay was $152.22 per ton. The average value of imported fire clay was $599.33 per ton.

Trade.—Exports of fire clay and refractory-grade kaolin appear to have been combined under the same HTS code in recent years. At least 43%, and possibly more, of the exports reported by the U.S. Census Bureau under the HTS code for fire clay was thought to be refractory-grade kaolin rather than fire clay based on the locations of ports from which the material was exported. In 2010, exports of fire clay and refractory-grade kaolin increased to 404,000 t valued at $61.5 million compared with 328,000 t valued at $42.8 million in 2009 (table 14). An increase in exports to Luxembourg, a major distribution center for European shipments, accounted for the largest share of the U.S. export increase. In 2010, imports were 299 t valued at $179,000 (table 15).

Outlook.—Sales of fire clay for refractory uses were expected to increase in 2011. The Federal Reserve indicated that industrial output increased in 2010 with the increase continuing into 2011 (Board of Governors of the Federal Reserve System, 2011). Major users of refractory products such as the aluminum, glass, iron, lime, and steel industries increased production in 2010 and 2011, suggesting an increased demand for refractory products for their furnaces. Sales of fire clay for refractory applications may increase slightly in 2011.

Sales of fire clay for construction-related products, such as brick, cement, lightweight aggregate, and tile, face the same issues as common clay and shale, a dependence on growth in the private housing and commercial construction sectors to support growth in heavy-clay markets. Sales of fire clay for these applications have been erratic in recent years, with producers of common clay venturing into and out of fire clay mining depending on their needs. Fire clay sales for heavy-clay products may increase slightly in 2011 compared with those of 2010 if construction activity increases.

Fuller's earth

Production.—In 2010, 12 companies produced fuller's earth in 11 States. Fuller's earth deposits grade from palygorskite (attapulgite) in Florida to montmorillonite further north in Georgia. Gellant grades of attapulgite, used as thickeners in such items as drilling muds and paints, were mined in western Florida and southwestern Georgia. Absorbent grades of attapulgite were mined further north in Georgia. Absorbent grades of attapulgite were grouped with the montmorillonite variety of fuller's earth in table 7 to be consistent with past reporting.

Gellant-grade attapulgite was mined or sold in the Florida Panhandle and southwestern Georgia by two companies. Attapulgite production data were withheld to avoid revealing company proprietary data, but production increased in 2010 compared with that of 2009. Florida led in the production of attapulgite, followed by Georgia.

Production of the montmorillonite variety of fuller's earth increased slightly to 2.05 Mt valued at $201 million in 2010 compared with 2.01 Mt valued at $206 million in 2009 (table 7). Montmorillonite-type fuller's earth was produced, in decreasing order of tonnage, in Georgia, Missouri, Virginia, Mississippi, California, Tennessee, Florida, Illinois, Nevada, Kansas, and Texas. Georgia, Mississippi, Missouri, and Virginia accounted for 74% of U.S. production.

Consumption.—Consumption of fuller's earth (excluding attapulgite-type fuller's earth) increased slightly in 2010. Pet waste absorbent was the leading market for fuller's earth, followed by oil and grease absorbents; civil engineering applications; clarifying, decolorizing, and filtering of animal, mineral, and vegetable oils and greases; fertilizer carriers; animal feed; unknown filler and extender uses; pesticide carriers; miscellaneous ceramics; paint; and water treatment (table 7). These markets were representative of those of montmorillonite-type fuller's earth, which accounted for most of the total fuller's earth sales. The leading use of attapulgite-type fuller's earth was in fillers, extenders, and binders. Fillers and extenders included, in decreasing order of tonnage, unknown filler and extender uses; pesticide carrier; paint; adhesives; animal feed; fertilizer carrier; and cosmetic, medical, and pharmaceutical applications. Fillers and extenders were followed by drilling mud; clarifying, decolorizing, and filtering of animal, mineral, and vegetable oils and greases; and oil and grease absorbents. Montmorillonite grades dominated sales to most fuller's earth markets but attapulgite accounted for most of the sales of fuller's earth, in decreasing order of tonnage, for adhesives; drilling mud; cosmetic, medical, and pharmaceutical applications; and paint. Table 7 indicates that sales of fuller's earth for pet waste absorbent increased by 14% to 1.38 million tons in 2010. That probably was an overestimate based on declining sales for pet waste absorbent from 2005 to 2009. From 80,000 to 110,000 t of pet waste absorbent sales may have been for oil absorbent use, based on increased industrial manufacturing activity in 2010.

Oil-Dri Corp. of America reported a 2% increase in value of its sales by its Business-to-Business Group (sales to companies that further process Oil-Dri's products) but a 4% decrease in tonnage sold for its fiscal year ending July 31. Sales in that group increased for fluid purification and animal health and nutrition and decreased for pet litter and agricultural chemical carriers; export sales also increased. Sales by Oil-Dri's Retail and Wholesale Products Group declined by 12% in value and 9% in tonnage. Cat litter accounted for most of the decline with additional slight decreases in the oil absorbent markets (Oil-Dri Corp. of America, 2011a, p. 28–29).

Prices.—The average unit value of attapulgite-type fuller's earth was withheld to avoid disclosing company proprietary data but the value was unchanged from that of 2009. The average value of montmorillonite-type fuller's earth was $98.35 per metric ton, a decrease from $102.71 per ton in 2009. The average value declined by 4% in 2010 mainly because one large producer reported a significantly lower unit value. Average values for other producers increased. The average value of exported fuller's earth was $353.56 per ton. The average value of imported fuller's earth was $80 per ton.

Trade.—In 2010, exports increased to 100,000 t valued at $35.4 million compared with 90,000 t valued at $28.5 million in 2009 (table 14). Imports of decolorizing earth and fuller's earth were 2,000 t valued at $160,900 in 2010 (table 15).

Outlook.—Pet waste absorbent is the leading market for fuller's earth. In early 2011, Oil-Dri indicated that its sales of fuller's earth for cat litter applications decreased in tonnage (Oil-Dri Corp. of America, 2011b, p. 17–18). Because Oil-Dri was the leading U.S. provider of fuller's earth for cat litter, it is likely that overall U.S. sales for this application may remain unchanged or decrease slightly in 2011.

The second leading market for fuller's earth is in oil and grease absorbents. These sales are tied to industrial output where increased heavy manufacturing and machining results in increased use of oil and grease absorbents. In early 2011, industrial output increased slightly (Board of Governors of the Federal Reserve System, 2011). This suggests that 2011 sales of fuller's earth for oil and grease absorbent applications may increase slightly compared with those of 2010.

According to Oil-Dri, sales as carriers and suspension agents in fertilizers and pesticides used for agriculture and lawn and garden products increased from mid-2010 to mid-2011 (Oil-Dri Corp. of America, 2011b, p. 17–18). This suggests that overall U.S. sales for this application may increase slightly in 2011.

Other uses for fuller's earth are relatively small in volume. Sales for clarifying, decolorizing, and filtering of animal, mineral, and vegetable oils and greases are dependent on the quality of the oil source, and sales tend to vary yearly rather than follow economic trends. Sales increased in 2010 and appeared to be doing the same in early 2011. Consequently, sales for fluid purification may increase slightly in 2011. Attapulgite-type fuller's earth was sold for construction-related filler and extender applications, such as in adhesives, asphalt emulsions, caulks, joint compounds, paint, and roof coatings. Because sales of these products are constrained by the slow housing markets, sales of attapulgite-type fuller's earth for construction-related products may increase only slightly in 2011. Sales for drilling mud applications may increase slightly in 2011 compared with those of 2010, based on global oil drilling activity.

In general, any improvement in the U.S. economy will likely result in slightly improved sales for nonabsorbent applications for fuller's earth in 2011.

Kaolin

Production.—In 2010, 19 firms mined kaolin in 9 States. Domestic production increased by 3% to 5.42 Mt valued at $788 million compared with 5.29 Mt valued at $714 million in 2009 (table 8). The leading producer State was Georgia, followed by, in descending order of tonnage, South Carolina, Alabama, Texas, Arkansas, Nevada, Florida, North Carolina, and California.

Of the 5.42 Mt sold or used in 2010, 2.28 Mt was reported as water washed, 1.34 Mt was calcined, 984,000 t was delaminated, 758,000 t was airfloat, and 58,000 t was unprocessed (table 8). Pigment-grade (low-temperature calcined kaolin) accounted for less than 50% of the tonnage of the total calcined kaolin sales. Actual sales of pigment-grade calcined kaolin were withheld to avoid revealing company proprietary data. Companies in Georgia accounted for nearly all the pigment-grade calcined kaolin produced in 2010. A small amount also was produced in Texas.

Kaolin production in Georgia increased slightly to 5.05 Mt valued at $757 million in 2010 compared with 4.97 Mt valued at $693 million in 2009. Approximately 2.20 Mt of Georgia kaolin production sold was reported as water washed, 1.24 Mt was calcined (high- and low-temperature calcined kaolin), 984,000 t was delaminated, and 621,000 t was airfloat in 2010 (table 9). Production in South Carolina increased by 10% to 158,000 t valued at $10.5 million in 2010 compared with 144,000 t valued at $8.59 million in 2009 (table 10). High-temperature calcined kaolin production increased because of increased demand from the refractory industry, and sales of delaminated and low-temperature calcined kaolin increased because of increased demand from the paper industry.

Imerys, one of the leading U.S. kaolin producers, indicated that global sales in most markets declined in 2010, although sales to paper applications increased by 6% globally as the printing and writing paper markets began to recover from the 2008–09 economic recession. Worldwide sales of kaolin for manufacturing, including adhesives, paint, plastics, and refractory products, increased in 2010. Construction markets in the United States remained flat while those in Europe increased (Imerys SA, 2011, p. 7–9).

Drilling activity in 2009–10 in Applied Minerals, Inc.'s Dragon Pit Mine, in the Tintic District of north-central Utah, indicated that resources totaled 552,000 t of halloysitic clay, averaging 65% halloysite, 18% kaolinite, and 10.6% illite and smectite. Some areas of the deposit contained up to 100% halloysite (Applied Minerals Inc., 2011).

Consumption.—Consumption of kaolin increased in 2010 from that of 2009 (table 8). The major domestic markets for kaolin were, in descending order of tonnage, paper coating and filling, refractory products, fiberglass and mineral wool, paint, catalyst manufacture, rubber, and heavy-clay products (brick and portland cement). Other smaller but significant markets were ceramics, chemical manufacture, and plastics (table 11). A similar market distribution was seen for producers in Georgia (table 9). The sales distribution for South Carolina kaolin producers was, in descending order of tonnage, catalyst manufacture (included in ceramics in table 10), rubber, brick, fiberglass, and plastics.

Paper coating and filling markets accounted for 57% of kaolin sales in 2010. Sales increased in response to increased manufacture of paper in the North America. Refractory products accounted for 13% of kaolin sales in 2010, with sales increasing because of increased U.S. industrial production. These two markets accounted for about 57% of the increase in kaolin sales in 2010. Other increases were distributed across many end-use markets.

Prices.—The average unit value of kaolin was $145.32 per metric ton for all kaolin grades. The average value for airfloat was $86.77 per ton; delaminated, $139.07 per ton; unprocessed, $14.19 per ton; and water washed, $145.56 per ton. Values for refractory-grade (high-temperature calcined) and pigment-grade (low-temperature calcined) kaolin were concealed to avoid revealing company proprietary data, but all types of calcined kaolin combined were valued at $188.45 per ton. The average value of exported kaolin was $217.18 per ton. The average value of imported kaolin was $236.67 per ton.

The price of number 1 paper coating grades of kaolin from a plant in Georgia ranged from $146 to $185 per ton, and the price of number 2 paper coating grades varied from $95 to $147 per ton (Industrial Minerals, 2010).

The annual average PPI for ball clay and kaolin mining under North American Industry Classification System code 2123240 was 182.9 in 2010 (1984=100) compared with 176.5 in 2008. The PPI was increased from 182 in January to 183.6 in December. The PPI measured the average change in the selling prices charged by domestic producers of ball clay and kaolin over time (U.S. Bureau of Labor Statistics, undated).

Trade.—Exports increased in 2010 as the economies of many countries began to improve. In 2010, 2.47 Mt of kaolin valued at $537 million was exported compared with 2.29 Mt valued at $459 million in 2009 (table 14). Producers reported exports of 1.45 Mt (table 11). Much of the kaolin exported to Canada and Mexico probably was reported under domestic consumption by U.S. producers. Sales through U.S. mineral brokers, where producers do not know if the kaolin is used domestically or exported, also could explain part of the discrepancy.

Kaolin imports were an estimated 239,000 t of kaolin valued at $56.3 million in 2010 compared with 281,000 t valued at $68.7 million in 2009 (table 15). Inaccuracies have been observed in kaolin import data from Brazil in the past, raising the possibility that imports in 2010 may have been higher. Some kaolin imports from Brazil may have been shipped to Canadian paper manufacturers via ports in New England and not used in the United States. About 94% of kaolin imports were from Brazil, followed by Canada and the United Kingdom. Imports from Brazil were primarily for paper coating applications, and those from the United Kingdom were primarily for paper filler applications.

Outlook.—Sales by the kaolin industry improved in 2010 after a large decline in 2009 because of the economic recession. An increase in global paper production contributed significantly to the expanding kaolin markets in 2010. Overall global paper production increased more than 6% in 2010 (Imerys SA, 2011). Year-to-date U.S. manufacturer's shipments from pulp, paper, and paperboard mills increased through mid-2011 compared with the same time period in 2010 (Board of Governors of the Federal Reserve System, 2011; U.S. Census Bureau, 2011c). Domestic sales of kaolin for paper applications may increase slightly in 2011. Export sales of kaolin, primarily for paper use, may increase slightly, particularly to Asian markets, where economic growth surpassed other parts of the world. Sales of paper for most applications increased in Europe (Confederation of European Paper Industries, 2011).

U.S. industrial manufacturing output increased in 2010 and through mid-2011 (Board of Governors of the Federal Reserve System, 2011). If this trend continues, sales of kaolin used to manufacture such products as catalysts, chemicals, plastics, refractory products (see discussion under Fire clay), and rubber may increase slightly in 2011 compared with 2010.

Commercial and residential construction remained slow in 2010 and early 2011. Residential construction increased only slightly in 2010 and through May 2011, but the value put in place for all forms of construction decreased (U.S. Census Bureau, 2011a, d, e, undated). Concerns about mortgage foreclosures, tight credit, proposed new lending laws, and continued uncertainty in U.S. debt issues hampered growth in the construction industry. Sales for construction-related applications, such as the manufacture of brick, electrical porcelain, fiberglass, floor and wall tile, paint, portland cement, roofing granules, and sanitaryware may increase only slightly in 2011 compared with those of 2010 if the construction trend continues through 2011.

World Review

World production of bentonite was approximately 10.7 Mt (table 16) and fuller's earth production was 3.36 Mt (table 17). Kaolin production was about 33.2 Mt (table 18), including ball clay from Australia, Ukraine, and various other countries, and crude kaolin ore production tonnages were reported by many countries. World sales of processed kaolin were estimated to be between 22 and 24 Mt, after accounting for processing losses and stockpiling and the inclusion of ball clay production under kaolin by some countries. The United States continued to be the leading supplier of processed clay for sale, followed by Turkey and Greece for bentonite, Spain for fuller's earth, and Brazil and the United Kingdom for kaolin. Spain led all countries in the production of sepiolite. Senegal was the leading producer of palygorskite (attapulgite), followed by the United States. The rankings above were based on processed clay sold or used and not on crude ore production.

Brazil.—Imerys purchased an 86% share of Pará Pigmentos S.A. (PPSA) from Vale S.A. The $70 million purchase included the kaolin deposits, a 400,000-t/yr processing plant, a harbor facility at Barcarena, and mining rights in the State of Pará. Imerys already owned Rio Capim Caulim, a leading Brazilian kaolin producer with 1.6 million metric tons per year (Mt/yr) of production capacity. Imerys' combined kaolin production capacity was 4.8 Mt/yr from operations in Australia, Brazil, France, New Zealand, Portugal, Thailand, Ukraine, the United Kingdom, and the United States. The purchase of PPSA increased Imerys' reserves of kaolin suitable for paper and packaging markets and was expected to allow the company to control long-term mining costs more effectively (O'Driscoll, 2010b; Imerys, 2011, p. 9).

India.—Ashapura Volclay Ltd. (a joint venture between Ashapura Minechem Ltd. and AMCOL International Corp.) announced that it began operating a third plant for producing acid-activated bleaching clay. The plant, in Kutch, Gujarat, had a capacity of 25,000 t/yr. With the opening of the plant, the joint venture had the capacity to produce more than 100,000 t/yr of bleaching clay and 10,000 t/yr of catalyst clay. All the clay used at this facility was calcium bentonite (O'Driscoll, 2010a).

South Africa.—G&W Mineral Resources (Pty.) Ltd. completed a new $6 million bentonite plant near Koppies, Free State Province. The plant enabled the company to process dry and wet ores and provided dry storage for the bentonite ore. Previously, the operation closed during rainy seasons because the company could not process wet ore and lacked adequate dry storage for bentonite ore (Roberts, 2011).

Ukraine.—Société Kaolinière Armoricaine (SOKA) announced that it would build a 75,000-t/yr kaolin plant near Pervomaisk, Mykolaiv. The plant was scheduled to be built in three stages, by increasing 25,000 t/yr at each stage. SOKA will process kaolin for ceramic markets. SOKA had been selling its crude kaolin for the manufacture of brick, tile, and white cement (Watts, 2010).

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TABLE 1
SALIENT U.S. CLAY STATISTICS[1, 2]

(Thousand metric tons and thousand dollars)

	2006	2007	2008	2009	2010
Domestic clays sold or used by producers:					
Quantity	41,200	36,700	32,700	24,500	25,400
Value	1,770,000	1,750,000	1,650,000	1,330,000	1,460,000
Exports:					
Quantity	5,980	5,650	5,100	3,830	4,360
Value	1,000,000	928,000	938,000	702,000	862,000
Imports for consumption:					
Quantity	346	231	237	325	284
Value	79,200	73,900	86,600	104,000	92,000

[1] Excludes Puerto Rico.

[2] Data are rounded to no more than three significant digits.

TABLE 2
CLAYS SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

	2009		2010	
State[3]	Quantity	Value	Quantity	Value
Alabama	1,340	25,300	1,450	29,900
Arkansas	539	7,630	579	8,210
California	340	4,690	570	33,300
Colorado	61	435	110	350
Florida	18	3,000	202	33,600
Georgia	5,600	697,000	6,300	819,000
Indiana	413	6,610	381	8,260
Iowa	184	828	201	827
Kansas	381	2,430	380	2,940
Kentucky	288	5,980	323	8,080
Louisiana	353	9,120	151	1,330
Michigan	318	1,310	312	1,290
Mississippi	263	1,540	642	35,600
Missouri	421	3,020	1,030	40,800
New York	605	30,200	595	30,000
North Carolina	828	4,980	856	5,300
Ohio	770	13,400	817	14,600
Oklahoma	572	2,800	554	2,600
Pennsylvania	451	3,040	344	2,490
South Carolina	455	9,890	426	11,700
Tennessee	624	23,600	776	32,300
Texas	1,850	21,600	2,080	48,600
Utah	342	7,230	482	11,800
Virginia	505	5,830	775	27,500
Wyoming	3,270	172,000	4,160	225,000
Other[4]	3,760	269,000	979	26,900
Total	24,500	1,330,000	25,400	1,460,000

[1] Excludes Puerto Rico.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Publishable totals used to avoid disclosing company proprietary data.

[4] Includes all other producer States.

TABLE 3

BALL CLAY SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY TYPE AND USE[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
	Quantity	Value	Quantity	Value
Type:				
Airfloat	588	26,000	629	27,500
Water-slurried	93	4,440	105	5,100
Unprocessed	151	7,230	178	8,680
Total	831	37,700	912	41,300
Use:				
Fillers, extenders, binders[2]	37	NA	40	NA
Floor and wall tile	299	NA	240	NA
Miscellaneous ceramics[3]	77	NA	85	NA
Pottery	4	NA	10	NA
Sanitaryware	181	NA	188	NA
Miscellaneous[4]	24	NA	156	NA
Exports, reported by producers[5]	209	NA	191	NA
Total	831	37,700	912	41,300

NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes asphalt emulsions; rubber; and other fillers, extenders, and binders.

[3] Includes catalysts, electrical porcelain, fiberglass, fine china/dinnerware, glass, mineral wool, and roofing granules.

[4] Includes heavy-clay products, waterproofing seals, refractories, and other unknown uses.

[5] Includes ceramics and glass and floor and wall tile.

TABLE 4

BENTONITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY TYPE AND USE[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
	Quantity	Value	Quantity	Value
Type:				
Nonswelling	116	8,140	123	9,320
Swelling	3,530	198,000	4,510	252,000
Total	3,650	207,000	4,630	261,000
Use:				
Domestic:				
Pet waste absorbents	925[e]	NA	967[e, 2]	NA
Adhesives	9	NA	8	NA
Animal feed	60	NA	71	NA
Drilling mud	587	NA	1,020[2]	NA
Filler and extender applications[3]	69	NA	104	NA
Foundry sand	443[e]	NA	423[e, 2]	NA
Pelletizing (iron ore)	445[e]	NA	595[e, 2]	NA
Waterproofing and sealing	102	NA	122	NA
Miscellaneous civil engineering	190[e]	NA	192[e]	NA
Miscellaneous[4]	170	NA	310	NA
Total	3,000[e]	NA	3,810[e]	NA
Exports, reported by producers:				
Drilling mud	105[e]	NA	160[e]	NA
Foundry sand	192	NA	121[2]	NA
Other[5]	349	NA	536	NA
Total	646[e]	NA	817[e]	NA
Grand total	3,650	207,000	4,630	261,000

[e] Estimated. NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] More information can be found in the Consumption section under Bentonite.

[3] Includes asphalt tiles, asphalt emulsions, cosmetics, fertilizers, ink, medical, miscellaneous fillers and extenders applications, paint, paper coating, paper filling, pesticides and related products, pharmaceuticals, and plastics.

[4] Includes ceramics, chemical manufacturing, clarifying and decolorizing, heavy-clay products, oil and grease absorbents, refractories, and other unknown uses.

[5] Includes absorbents, fillers and extenders, refractories, pelletizing, and other unknown uses.

TABLE 5
COMMON CLAY AND SHALE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE AND USE[1, 2]

(Thousand metric tons and thousand dollars)

	2009		2010	
	Quantity	Value	Quantity	Value
State:				
Alabama	1,340	25,300	1,300	21,500
Arkansas	539	7,630	534	7,580
California	318	2,370	355	5,000
Georgia	631	3,870	657	3,910
Indiana	413	6,610	358	7,110
Kansas	381	2,430	353	1,850
Kentucky	288	5,980	284	5,780
Louisiana	353	9,120	151	1,330
Mississippi	263	1,540	259	1,540
Missouri	421	3,020	412	3,060
New York	605	30,200	595	30,000
North Carolina	828	4,980	846	4,890
Ohio	770	13,400	814	14,600
Oklahoma	572	2,800	554	2,600
Pennsylvania	451	3,040	343	2,490
South Carolina	311	1,300	267	1,190
Texas	1,800	13,000	1,740	14,000
Utah	342	7,230	322	7,020
Virginia	505	5,830	503	6,010
Other[3]	1,330	6,170	1,410	6,220
Total	12,500	156,000	12,100	148,000
Use:				
Floor and wall tile[4]	181	NA	358	NA
Heavy-clay products:				
Brick, extruded	5,680	NA	5,380	NA
Brick, other	547	NA	608	NA
Other[5]	165	NA	55	NA
Lightweight aggregate:				
Concrete block	1,310	NA	1,340	NA
Highway surfacing	483	NA	561	NA
Structural concrete	731	NA	701	NA
Miscellaneous	597	NA	266	NA
Portland and other cements	1,900	NA	2,070	NA
Refractories[6]	360	NA	364	NA
Miscellaneous[7]	493	NA	353	NA
Total	12,500	156,000	12,100	148,000

NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes Puerto Rico.

[3] Includes all other States except Alaska, Delaware, Hawaii, Idaho, Nevada, New Hampshire, Rhode Island, Vermont, and Wisconsin.

[4] Includes ceramic tile, quarry tile, and miscellaneous floor and wall tiles.

[5] Includes drain tile, flower pots, flue linings, sewer pipe, structural tile, and miscellaneous clay products.

[6] Includes firebrick, blocks and shapes, mortar and cement, grogs and calcines, and miscellaneous refractories.

[7] Includes exports, reported by producers; miscellaneous civil engineering and sealings; miscellaneous fillers, extenders, and binders; pottery; roofing granules; and other unknown uses.

TABLE 6

FIRE CLAY SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
	Quantity	Value	Quantity	Value
Production	320	12,000	216	6,120
Use:				
Heavy-clay products and lightweight aggregates[2]	146	NA	123	NA
Refractories:				
Firebrick, block, shapes	19	NA	19	NA
Grogs and calcines	W	NA	W	NA
Other refractories[3]	W	NA	W	NA
Miscellaneous[4]	155	NA	74	NA
Total	320	12,000	216	6,120

NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes common brick, concrete block, portland cement, and structural concrete.

[3] Includes kiln furniture, mortar and cement, and miscellaneous refractories.

[4] Includes floor tile, wall tile, and other unknown uses.

TABLE 7

FULLER'S EARTH SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY TYPE AND USE[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
	Quantity	Value	Quantity	Value
Type:				
Attapulgite	(2)	(2)	(2)	(2)
Montmorillonite	2,010	206,000	2,050	201,000
Total	2,010	206,000	2,050	201,000
Use:				
Absorbents:				
Oil and grease absorbent	255	NA	153	NA
Pet waste absorbent	1,220	NA	1,380	NA
Animal feed	63	NA	54	NA
Fertilizers	W	NA	W	NA
Fillers, extenders, binders[3]	107	NA	111	NA
Filtering, clarifying, and decolorizing[4]	72	NA	89	NA
Miscellaneous[5]	261	NA	223	NA
Exports, reported by producers[6]	33	NA	34	NA
Total	2,010	206,000	2,040	201,000

NA Not available. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Withheld to avoid disclosing company proprietary data. Primarily gellant-grade fuller's earth. More information can be found in the "Fuller's Earth" portion of this report.

[3] Includes asphalt emulsions; medical, pharmaceuticals and cosmetics; paints; pesticides and related products; and other unknown uses.

[4] Includes mineral and vegetable oils and greases.

[5] Includes civil engineering, drilling mud, miscellaneous absorbents, and other unknown uses.

[6] Includes oil and grease absorbents, pet waste absorbents, drilling mud, paint, and other unknown uses.

TABLE 8
KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE AND TYPE[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
	Quantity	Value	Quantity	Value
State:				
Georgia	4,970	693,000	5,050	757,000
South Carolina	144	8,590	158	10,500
Other[2]	180	12,700	214	20,500
Total	5,290	714,000	5,420	788,000
Type:				
Airfloat	894	73,200	758	65,800
Calcined[3]	1,180	203,000	1,340	252,000
Delaminated	824	118,000	984	137,000
Unprocessed	55	1,190	58	823
Water washed	2,330	319,000	2,280	332,000
Total	5,290	714,000	5,420	788,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Alabama, Arkansas, California, Florida, Nevada, North Carolina, and Texas.

[3] Includes pigment-grade kaolin (low-temperature calcined kaolin) and refractory-grade kaolin (high-temperature calcined kaolin).

TABLE 9
GEORGIA KAOLIN SOLD OR USED BY PRODUCERS, BY TYPE AND USE[1]

(Thousand metric tons and thousand dollars)

Kind	2009		2010	
	Quantity	Value	Quantity	Value
Type:				
Airfloat	761	62,400	621	54,100
Calcined[2]	1,100	195,000	1,240	242,000
Delaminated	824	118,000	984	137,000
Water washed	2,280	318,000	2,200	324,000
Total	4,970	693,000	5,050	757,000
Use:				
Domestic:				
Ceramics and glass:				
Catalysts (oil-refining)	W	NA	W	NA
Fiberglass, mineral wool	217	NA	185	NA
Roofing granules	34	NA	27	NA
Other[3]	296	NA	820	NA
Fillers, extenders, binders:				
Adhesives	17	NA	19	NA
Paint	164	NA	176	NA
Paper coating	1,560	NA	1,460	NA
Paper filling	196	NA	75	NA
Plastic	57	NA	21	NA
Rubber	121	NA	118	NA
Other[4]	38	NA	48	NA
Heavy-clay products[5]	(6)	NA	(6)	NA
Refractories[7]	(6)	NA	(6)	NA
Undistributed[8]	757	NA	785	NA
Total	3,460	NA	3,730	NA
Exports, reported by producers:				
Paint	53	NA	48	NA
Paper coating[9]	1,260	NA	1,070	NA
Paper filling[9]	46	NA	37	NA
Rubber	41	NA	36	NA
Undistributed[10]	105	NA	125	NA
Total	1,500	NA	1,320	NA
Grand total	4,970	693,000	5,050	757,000

NA Not available. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes pigment- and refractory-grade calcined kaolin.

[3] Includes catalysts (oil-refining), electrical porcelain, fine china/dinnerware, pottery, miscellaneous ceramics, and sanitaryware.

[4] Includes animal feed; asphalt tile; fertilizers; medical, pharmaceuticals, and cosmetics; pesticides and related products; and miscellaneous fillers, extenders, and binders.

[5] Includes brick (common and face), portland cement, and miscellaneous clay products.

[6] Withheld to avoid disclosing company proprietary data; included in "Domestic: Undistributed."

[7] Includes firebricks, blocks and shapes, grogs and calcines, high-alumina specialties, kiln furniture, and miscellaneous refractories.

[8] Includes absorbents, chemical manufacturing, floor and wall tiles, heavy-clay products, refractory products, waterproofing seals, and other unknown uses.

[9] Some export sales, by producers, may be included under domestic sales.

[10] Includes miscellaneous ceramics and miscellaneous fillers, extenders, and other unknown uses.

TABLE 10

SOUTH CAROLINA KAOLIN SOLD OR USED BY PRODUCERS, BY USE[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
	Quantity	Value	Quantity	Value
Production[2]	144	8,590	158	10,500
Use:				
Ceramics[3]	68	NA	67	NA
Rubber	30	NA	31	NA
Other uses[4]	46	NA	60	NA
Total	144	8,590	158	10,500

NA Not available.

[1] Data are rounded to no more than three significant digits, may not add to totals shown.

[2] Includes airfloat, unprocessed, and calcined kaolin.

[3] Includes catalysts (oil-refining), fiberglass, roofing granules, and sanitaryware.

[4] Includes adhesives, animal feed, brick (common), exports, floor and wall tile, paper coating, plastics, and refractories.

TABLE 11

KAOLIN SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

(Thousand metric tons)

Use	2009	2010
Domestic:		
Ceramics:		
Catalyst (oil and gas refining)	233	179
Electrical porcelain	W	W
Fine china and dinnerware	7	6
Floor and wall tile	82	84
Pottery	W	W
Roofing granules	34	35
Sanitaryware	35	42
Miscellaneous ceramics	84	54
Chemical manufacture	W	W
Fiberglass, mineral wool	224	244
Fillers, extenders, binders:		
Adhesive	19	20
Fertilizer	W	W
Paint	176	190
Paper coating	1,570	1,720
Paper filling	196	149
Pesticide	W	W
Plastic	63	50
Rubber	150	172
Miscellaneous fillers, extenders, binders	39	44
Heavy–clay products:		
Brick, common and face	54	37
Portland cement	55	86
Refractories[2]	614	695
Miscellaneous applications	137	167
Total	3,770	3,970
Exports, reported by producers:		
Ceramics[3]	W	W
Paint	61	84
Paper coating	1,260	1,190
Paper filling	46	44
Rubber	45	40
Miscellaneous	107	91
Total	1,520	1,450
Grand total	5,290	5,420

W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous ceramics and Miscellaneous fillers, extenders, binders."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes firebrick (blocks and shapes), grogs and calcines, and miscellaneous refractories.

[3] Withheld to avoid disclosing company proprietary data; included in "Exports, reported by producers: Miscellaneous."

TABLE 12
COMMON CLAY AND SHALE USED IN LIGHTWEIGHT AGGREGATE PRODUCTION IN THE UNITED STATES BY STATE[1]

(Thousand metric tons and thousand dollars)

State	Concrete block	Structural concrete	Other[2]	Total	
				Quantity	Value[e]
2009:					
Alabama	356	25	43	424	14,900
Arkansas	130	32	--	162	6,250
Indiana	91	54	72	218	6,000
Kansas	--	--	62	62	541
Kentucky	46	38	--	84	4,660
Louisiana	132	53	129	314	8,820
Missouri	--	--	124	124	1,080
Nebraska	--	--	1	1	3
New York	153	257	--	411	26,200
Ohio	72	40	68	179	7,700
Oklahoma	20	3	--	23	714
Texas	156	168	409	733	5,270
Utah	93	58	149	300	7,050
Virginia	67	1	23	90	2,060
Total	1,310	731	1,080	3,130	91,300
2010:					
Alabama	361	25	43	430	11,900
Arkansas	128	32	--	160	6,240
Indiana	63	32	65	162	6,500
Kansas	19	3	201	28	188
Kentucky	44	36	--	80	4,470
Louisiana	62	19	29	110	1,030
Missouri	22	18	63	103	1,110
Nebraska	--	--	454	454	2
New York	163	272	--	435	28,200
Ohio	72	40	68	180	7,820
Oklahoma	20	3	--	25	703
Texas	149	161	385	699	5,540
Utah	91	57	112	260	5,820
Virginia	145	2	51	196	4,490
Total	1,340	700	1,470	3,320	84,000

[e] Estimated. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes highway surfacing.

TABLE 13
COMMON CLAY AND SHALE USED IN BUILDING BRICK PRODUCTION IN THE UNITED STATES, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

State	2009		2010	
	Quantity	Value[e]	Quantity	Value[e]
Alabama	571	6,950	541	6,210
Arkansas	147	705	22	47
California	120	734	117	710
Colorado	42	309	93	242
Georgia	581	3,620	607	3,670
Kentucky[3]	200	1,210	200	1,210
Mississippi	263	1,540	259	1,540
North Carolina	828	4,980	621	2,830
Ohio	405	4,770	439	4,990
Oklahoma	415	1,720	404	1,540
Pennsylvania	398	2,230	288	1,650
South Carolina	301	1,250	257	1,140
Tennessee	113	817	114	817
Texas	429	2,150	457	2,460
Virginia	312	1,420	306	1,520
Other[4]	1,110	6,590	1,270	7,260
Total	6,230	41,000	6,000	37,800

[e] Estimated.

[1] Includes extruded and other brick.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Extruded brick only.

[4] Includes all other States except for Alaska, Nevada, New Hampshire, Rhode Island, Vermont, and Wisconsin.

TABLE 14
U.S. EXPORTS OF CLAYS, BY TYPE[1]

(Thousand metric tons and thousand dollars)

Material	2009		2010		Principal destinations in 2010
	Quantity	Value	Quantity	Value	
Ball clay	35	2,430	45	3,030	Mexico, 40%; Venezuela, 15%; Costa Rica, 12%.
Bentonite	709	100,000	953	143,000	Canada, 45%; Japan, 11%; Saudi Arabia, 8%; China, 6%.
Fire clay	328	42,800	404	61,500	Mexico, 54%; Luxembourg, 22%; Japan, 9%.
Fuller's earth	90	28,500	100	35,400	Japan, 20%; China, 10%; United Kingdom, 8%.
Kaolin	2,290	459,000	2,470	537,000	Japan, 17%; Canada, 13%; Chile, 11%; Finland, 11%; Mexico, 11%.
Clays, n.e.c.	374	69,500	383	82,600	Canada, 70%.
Total	3,830	702,000	4,360	862,000	

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 15

U.S. IMPORTS FOR CONSUMPTION OF CLAY, BY TYPE[1]

(Thousand metric tons and thousand dollars)

Material	2009		2010		Principal sources in 2010
	Quantity	Value	Quantity	Value	
China clay or kaolin	281	68,700	239	56,300	Brazil, 94%.
Fire clay	(2)	133	(2)	179	Canada, 50%; Germany, 48%.
Decolorizing earths and fuller's earth	1	96	2	160	Japan, 79%; China, 21%.
Bentonite	8	2,460	16	4,670	Greece, 46%; Mexico, 23%; Canada, 17%.
Common blue clay and other ball clay	--	--	1	138	United Kingdom, 70%; Canada, 30%.
Other clay	8	3,940	7	4,560	Peru, 41%; Canada, 38%.
Chamotte or Dina's Earth	(2)	165	(2)	110	Czech Republic, 69%; Sweden, 21%.
Artificially activated clay and earth	27	28,800	19	25,800	Mexico, 70%; Germany, 17%.
Total	325	104,000	284	92,000	

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau; as adjusted by U.S. Geological Survey.

TABLE 16
BENTONITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Algeria[4]	27,100	32,600	30,600	31,000	31,000
Argentina	246,000	250,000	256,000	148,000 [r]	200,000
Armenia[e]	720	1,130	50 [r]	238 [r]	1,400 [5]
Australia[e, 4]	220,000	255,000	250,000	240,000	230,000
Azerbaijan[e]	40,600	50,500	40,700 [r]	10,600 [r]	18,100 [5]
Bolivia	--	--	1 [r]	323 [r]	440 [5]
Bosnia and Herzegovina	24,600	32,900	30,500	16,000 [r]	16,000
Brazil, beneficiated	235,000	330,000 [r]	340,000 [r]	264,000 [r]	265,000
Bulgaria	134,000	99,000	178,000	108,000 [r]	110,000
Burma	904	971	1,000 [e]	1,000 [e]	1,000
Chile	--	533	--	--	--
Croatia	16,400	19,600	19,800 [r]	-- [r]	--
Cyprus	150,000	150,000	150,000	150,000	150,000
Czech Republic	267,000	335,000	174,000 [e]	116,000	183,000
Egypt[e]	30,000	29,800 [5]	32,000 [5]	32,000	30,000
Georgia[e]	4,490 [5]	5,000	5,000	5,000	5,000
Germany	364,000	385,000	414,000	326,000 [r]	350,000
Greece[e]	1,130,000 [5]	950,000	1,500,000 [r]	845,000 [r, 5]	850,000
Guatemala	20,000	23,600	62,700	14,300 [r]	22,400 [5]
Hungary	6,600	54,000	50,000	45,000 [r, e]	50,000
Indonesia[e]	5,500	5,500	6,000	6,000	6,500
Iran[6]	260,000	254,000 [5]	358,000 [r, 5]	380,000 [r]	400,000
Italy[e]	470,000	306,000 [r]	281,000	146,000	111,000
Japan	425,000	430,000	435,000	432,000	430,000
Kenya[e]	60	70	70	70	70
Macedonia[e]	32,500	35,200	22,900	15,400 [r]	15,400
Malawi	--	2,080	7,020	8,050	1,020
Mexico	435,000	614,000	375,000	511,000 [r]	591,000
Morocco	80,400	81,000	80,000	80,000	80,000
Mozambique	3,520	10,500 [r]	17,700 [r]	7,390 [r]	12,000
New Zealand, processed[e]	3,030	6,150	753	880	900
Pakistan	23,800	32,400 [r]	33,000 [r]	34,000 [r]	35,000
Peru	19,000	21,500	31,600	119,000	44,300 [5]
Philippines	1,000 [e]	1,150	1,420	1,410 [r]	1,500
Poland[7]	93,900	106,000	121,000	81,400 [r]	81,000
Romania	21,200	16,900	16,600 [r]	13,800 [r]	14,000
Serbia	-- [r]	-- [r]	-- [r]	-- [r]	--
Slovakia	136,000	149,000	145,000	109,000 [r]	110,000
South Africa[8]	32,900	45,800	44,100	40,300	54,300 [5]
Spain[e]	155,000 [5]	155,000	155,000	155,000	155,000
Turkey	1,130,000 [r]	1,740,000 [r]	1,550,000 [r]	932,000 [r]	1,200,000
Turkmenistan[e]	50,000	50,000	50,000	50,000	50,000
Ukraine[e]	300,000	300,000	200,000 [r]	195,000 [r]	200,000
United States	4,940,000	4,820,000	5,030,000	3,650,000	4,630,000 [5]
Zimbabwe[8]	500	100	100	-- [r, e]	--
Total	11,500,000 [r]	12,200,000 [r]	12,500,000 [r]	9,320,000 [r]	10,700,000

[e] Estimated. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 16—Continued

BENTONITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

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[2] Table includes data available through September 25, 2011.

[3] In addition to the countries listed, Canada and China are thought to produce bentonite, but output is not reported, and available information is inadequate to make reliable estimates of output levels.

[4] Includes bentonitic clays.

[5] Reported figure.

[6] Year beginning March 21 of that stated.

[7] Montmorillite type bleaching clay.

[8] May include other clays.

TABLE 17

FULLER'S EARTH: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Australia, attapulgite[e]	10,000	10,000	10,000	9,500	10,000
Guatemala	19	109	--	--	-- [4]
Italy[e]	3,000	3,000	3,000	3,000	3,000
Mexico	102,400	34,175	66,123	108,139	179,000
Morocco, smectite[e]	15,000	15,000	15,000	15,000	15,000
Pakistan	15,848 [r]	12,884 [r]	13,000 [r, e]	15,000 [r, e]	17,000
Senegal, attapulgite	140,000	150,000 [e]	167,000	180,000 [r]	204,000
South Africa, attapulgite	49,225	68,377	69,876	54,418 [r]	65,336 [4]
Spain:[e]					
Attapulgite	20,000	20,000	20,000	20,000	20,000
Sepiolite	800,000	800,000	800,000	800,000	800,000
United States[5, 6]	2,540,000	2,600,000	2,340,000	2,010,000	2,050,000 [4]
Total	3,700,000	3,720,000	3,500,000 [r]	3,210,000	3,360,000

[e]Estimated. [r]Revised. -- Zero.

[1] Excludes centrally planned economy countries and former such countries, some of which presumably produce fuller's earth but for which no information is available. Table includes data available through September 25, 2011.

[2] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[3] In addition to the market economy countries listed, France, India, Iran, Japan, and Turkey have reportedly produced fuller's earth in the past and may continue to do so, but output is not reported, and available information is inadequate to make reliable estimates of output levels.

[4] Reported figure.

[5] Sold or used by producers.

[6] Excludes attapulgite.

TABLE 18
KAOLIN: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Algeria	32,523	106,567	50,788	50,000[e]	50,000
Argentina	49,619	69,354	55,000	78,792[r]	75,000
Australia, includes ball clay[e]	250,000	250,000	230,000	230,000	240,000
Austria, marketable	51,900	56,690	49,527	83,980[r]	80,000
Bangladesh[e, 4]	8,500	8,600	8,500	8,500	8,500
Belgium[e]	300,000	300,000	300,000	300,000	300,000
Bosnia and Herzegovina, crude	69,643	188,033	259,325	148,384[r]	150,000
Brazil, beneficiated	2,455,000	2,456,000[r]	2,674,000	1,987,000[r]	2,000,000[p]
Bulgaria	1,658,000	1,631,000	1,530,000	939,000[r]	940,000
Chile	44,642	87,901	63,526	48,354	62,226[5]
Czech Republic	3,768,000	3,604,000	3,833,000	2,886,000	3,493,000[5]
Denmark, sales[e]	2,500	2,500	2,500	2,500	2,500
Ecuador	11,504	18,618	15,000[r, e]	15,000[r, e]	15,000
Egypt	416,000[e]	331,671	523,327	550,000	500,000
Eritrea	100	100	100	100	100
Ethiopia	1,641	1,400[e]	1,275	3,534	3,600
France, marketable[e]	300,000	307,253[5]	300,000	300,000	300,000
Germany	3,815,173	3,842,514	3,622,159[r]	4,513,753[r]	4,500,000
Greece[e]	50,000	40,000	4,360	--[5]	--
Guatemala	4,395	2,663	2,803	1,879	2,143[5]
Hungary, processed	7,000	3,000	3,000	2,800[r, e]	3,000
India:[e]					
Processed	200,000	200,000	210,000	210,000	220,000
Salable crude	560,000	570,000	570,000	580,000	580,000
Indonesia[e]	15,000	15,000	15,000	15,000	15,000
Iran[e]	310,000	350,000	320,000	320,000	330,000
Italy, kaolinitic earth	469,702	635,297	591,298	1,069,938	641,000
Japan	10,500	11,000	11,000[e]	12,000[e]	12,000
Jordan	112,787	101,000	181,018	177,470	180,000[5]
Kenya	810	900[r]	930[r]	890[r]	900
Korea, Republic of	2,399,458	688,330	954,584	659,351[r]	764,008[5]
Kyrgyzstan[e]	400,000	400,000	400,000	400,000	400,000
Malawi	920	1,000	1,100	--	--
Malaysia	341,223	587,508	506,462	463,732[r]	530,331[5]
Mexico	961,800	86,784	85,091	78,086	120,094[5]
New Zealand	14,864	14,130	12,761	9,016	10,000
Nigeria[e]	100,000	100,000	100,000	100,000	100,000
Pakistan	443,402[r]	756,536[r]	750,000[r]	760,000[r]	770,000
Paraguay[e]	66,000	66,000	66,000	66,000	66,000
Peru	5,750	7,532	13,215	9,347	16,678[5]
Poland, washed	144,000[r]	153,000[r]	166,000[r]	143,000[r]	145,000
Portugal	167,792	183,598	231,346[r]	274,925[r]	284,715[5]
Romania	11,063	7,576	3,166[r]	1,000[e]	1,000
Russia, concentrate[e]	45,000	45,000	45,000	45,000	45,000
Saudi Arabia	4,000	4,400	4,400	5,000[r, e]	5,000
Serbia:[e]					
Crude	110,000	110,000	110,000	110,000	110,000
Washed	18,000	10,000	10,000	10,000	10,000

See footnotes at end of table.

TABLE 18—Continued
KAOLIN: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Slovakia	58,000	46,000	44,000	10,000 [r]	10,000
South Africa	51,602	50,839	39,505	31,048	29,929 [5]
Spain, marketable, crude and washed[6]	464,049	450,000	465,000	465,000	485,000
Sri Lanka	10,914	11,178	10,039	10,000 [e]	11,000
Thailand, beneficiated	157,900	159,186	162,215	160,000 [e]	160,000
Turkey	1,064,107	914,117	792,044 [r]	727,649 [r]	800,000
Uganda[e]	30,000	30,000	30,000	30,000	30,000
Ukraine	1,731,000	2,172,000	1,775,000	1,119,000	1,120,000
United Kingdom, sales[7]	1,800,000	1,800,000	1,800,000	1,800,000	900,000
United States[8]	7,470,000	7,110,000	6,740,000	5,290,000	5,420,000 [5]
Uzbekistan[e]	5,500,000	5,500,000	5,500,000	5,500,000	5,500,000
Venezuela[e]	10,000	10,000	10,000	10,000	10,000
Vietnam[e]	650,000	650,000	650,000	650,000	650,000
Zambia[e]	200	200	200	200	200
Total	39,200,000 [r]	37,300,000 [r]	36,900,000 [r]	33,500,000 [r]	33,200,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through September 25, 2011.

[3] In addition to the countries listed, China, Morocco, and Suriname may also have produced kaolin, but information is inadequate to make reliable estimates of output levels.

[4] Data for year ending June 30 of that stated.

[5] Reported figure.

[6] Includes crude and washed kaolin and refractory clays not further described.

[7] Dry weight.

[8] Kaolin sold or used by producers.

COBALT

By Kim B. Shedd

Domestic survey data and tables were prepared by Cheryl J. Crawford, statistical assistant, and the world production tables were prepared by Lisa D. Miller and Glenn J. Wallace, international data coordinators.

In 2010, world production of refined cobalt increased by 28% to a record quantity of more than 76,000 metric tons (t). The increase was the result of significant increases in production from many countries, including China, the world's leading cobalt refiner. The United States did not refine cobalt in 2010. A negligible amount of byproduct cobalt was produced as an intermediate product from the mining and refining of platinum-group metal (PGM) ore. No cobalt was sold from the National Defense Stockpile (NDS) in 2010. Prior to 2010, the NDS had sold cobalt every year since cobalt sales began in 1993.

According to the Cobalt Development Institute (2011), world apparent consumption of cobalt was approximately 61,000 t, about 9% more than that of 2009. Apparent consumption increased in China, Europe, other Asia, and the United States. While Chinese consumption did increase from that of 2009, some of that country's apparent consumption was the result of a stockpile of 21,000 t of contained cobalt that had been accumulating since 2008 (Xu, 2011, p. 7). Cobalt prices trended downward in 2010. Salient U.S. and world cobalt statistics for 2006–10 are listed in table 1.

Cobalt is a metal used in numerous diverse commercial, industrial, and military applications, many of which are considered strategic and critical. On a global basis, the leading use of cobalt is in rechargeable battery electrodes. Superalloys, which are used to make parts for gas turbine engines, are another major use for cobalt. Cobalt is also used to make airbags for automobiles; catalysts for the petroleum and chemical industries; cemented carbides (also called hardmetals) and diamond tools; corrosion- and wear-resistant alloys; drying agents for inks, paints, and varnishes; dyes and pigments; ground coats for porcelain enamels; high-speed steels; magnetic recording media; magnets; and steel-belted radial tires.

Legislation and Government Programs

The Defense Logistics Agency (DLA), U.S. Department of Defense, changed the name of the Defense National Stockpile Center to DLA Strategic Materials. Early in fiscal year 2010 (October 1, 2009, through September 30, 2010), DLA sold 6 t of cobalt metal valued at $284,000 under a basic ordering agreement (BOA); no cobalt was sold during calendar year 2010 (table 2). The fiscal year sales represented only 1% of the 454-metric-ton (1-million-pound) maximum allowed for sale under the 2010 Annual Materials Plan (AMP). The AMP for fiscal year 2011 (October 1, 2010, through September 30, 2011) was reduced to 301 t (663,709 pounds), which was equal to the total uncommitted cobalt inventory held by DLA on December 31, 2010. Sales of cobalt were curtailed in order to hold a goal quantity equivalent to 1 year's AMP (U.S. Department of Defense, 2011, p. 2, 6–7, 9).

The U.S. Department of Energy released a strategy on critical materials used in clean energy technologies. Although included in the strategy because of its use in batteries for electric vehicles, cobalt was identified as "not critical" in terms of risk of supply disruption in the short (0–5 years) or medium (5–15 years) term, owing to a forecast of significant increases in global production (U.S. Department of Energy, 2010).

Production

With the exception of negligible amounts of byproduct cobalt produced from Stillwater Mining Co.'s PGM operation in southeastern Montana, the United States did not mine or refine cobalt in 2010. Cobalt-bearing nickel sulfate produced from Stillwater's mining and refining operations was sold to several companies. In late 2010, OJSC MMC Norilsk Nickel (Stillwater Mining's majority shareholder) sold all of its equity interest in the company to an unspecified number of investors (Stillwater Mining Co., 2011, p. 9, 26).

Formation Metals Inc. completed stage 1 construction of its Idaho cobalt mine, which consisted primarily of clearing timber from the site in preparation for laying foundations for mine site structures. The company continued to actively pursue financing for further construction, and received certificates of allocation from the State of Idaho for $77.7 million in Federal Stimulus Program Recovery Zone Facility Bonds. Formation's Idaho Cobalt Project entailed an underground cobalt-copper-gold mine and mill complex in the Idaho Cobalt Belt in Lemhi County and retrofitted Big Creek hydrometallurgical complex near Kellogg, ID, to refine the concentrates. The refinery was to produce approximately 1,500 metric tons per year (t/yr) of cobalt as high-grade cathode suitable for critical superalloy applications. Formation estimated that construction would take 12 to 14 months to complete (Formation Metals Inc., 2011, p. 5–9).

Kennecott Minerals Co., a fully owned subsidiary of Rio Tinto (Melbourne, Australia, and London, United Kingdom), began construction at its Eagle project in Michigan. The small underground nickel-copper mine in the Eagle deposit in the Yellow Dog Plains area northwest of Marquette and rehabilitated mill in Humboldt Township would produce concentrate for export. At the proposed rate of 17,300 t/yr of nickel, an estimated 400 t/yr of cobalt would be produced during a 6-year mine life, based on nickel and cobalt grades in the resource. Kennecott planned to begin production in late 2013 (Kennecott Eagle Minerals Co., 2010).

The Minnesota Department of Natural Resources, U.S. Army Corps of Engineers, and U.S. Forest Service were preparing a supplemental draft environmental impact statement for PolyMet Mining Corp.'s NorthMet project. The project entailed open pit mining of the NorthMet polymetallic deposit in the Duluth Complex of northeastern Minnesota, refurbishing the crushing and grinding equipment in the company's nearby Erie plant, and adding a new beneficiation circuit and hydrometallurgical plant. PolyMet planned to develop the project in stages and sell separate copper and nickel concentrates during the construction and commissioning of the hydrometallurgical plant, which would produce copper cathode, a nickel-cobalt mixed hydroxide, and a precipitate of PGMs and gold. PolyMet and Swiss trading firm Glencore International AG had a strategic partnership whereby Glencore would invest in Polymet and purchase or market NorthMet's concentrates, intermediate products, and metal (PolyMet Mining Corp., 2011, p. 11–12, 24–25).

U.S. processors made cobalt chemicals and cobalt metal powders from refined cobalt materials and (or) cobalt-bearing scrap. U.S. Geological Survey (USGS) data on chemical and metal powder production, shipments, and stocks were derived from a monthly voluntary survey of U.S. cobalt processors. Information from this survey was used to prepare the statistics on cobalt consumption and stocks in table 3. The sole producer of cobalt metal powder, Global Tungsten & Powders Corp. of Towanda, PA, produced the cobalt as a byproduct of tungsten recovered from cemented carbide scrap. U.S. production and shipments of cobalt metal powder are withheld to avoid disclosing company proprietary data.

Consumption

U.S. apparent consumption for 2010, as calculated from net imports, consumption from purchased scrap, and changes in Government and industry stocks, was 36% higher than that of 2009 (table 1). The increase was primarily because net imports in 2010 were significantly higher than those of 2009.

U.S. reported consumption of cobalt in 2010 was 8% higher than that of 2009. Metallurgical industries used 9% more cobalt than in 2009; cobalt consumption for chemical uses was 3% higher. Reported consumption was derived by the USGS from voluntary surveys of U.S. operations. Most of the data on cobalt chemical uses were obtained from the cobalt processors survey. A second survey covered a broad range of metal-consuming companies, such as cemented carbide, magnetic alloy, and superalloy producers. For this survey, more than 60 cobalt consumers were canvassed on a monthly or annual basis. Reported consumption and stocks data in tables 1 and 3 contain estimates to account for nonrespondents.

Prices

The annual average U.S. spot price for cathode (minimum of 99.8% cobalt), as reported by Platts Metals Week, was 17% higher than that of 2009 (table 1). Although the price fluctuated during the year, the overall trend was downward. The highest price was $23.50 to $24.50 per pound in mid-April, and the lowest price was $16.00 to $17.25 per pound in late November.

Trends in Platts' prices for Zambian cobalt (minimum 99.6% cobalt) and Russian cobalt (minimum 99.3% cobalt) were similar to those for U.S. spot cathode. The annual average of weekly prices for Zambian cobalt was $19.22 per pound, and the annual average of weekly prices for Russian cobalt was $19.44 per pound.

The London Metal Exchange (LME) launched a cobalt futures contract in February. Cobalt metal was traded in 1-metric-ton lots (in 100- to 500-kilogram drums) of minimum 99.3% cobalt with impurities specified by the producer for each LME approved brand, to warehouses in Antwerp, Baltimore, Rotterdam, and Singapore. The transactions were by open outcry ring trading, on an electronic trading platform, and by an interoffice telephone market. By yearend, cobalt from the following 11 producers had been approved for delivery: Jiangsu Cobalt Nickel Metal Co. Ltd., Jinchuan Group Ltd., Kasese Cobalt Co. Ltd., Mopani Copper Mines Plc, Nicomet Industries Ltd., OJSC MMC Norilsk Nickel, Sichuan Ni & Co Guorun New Materials Co. Ltd., Sumitomo Metal Mining Co., Ltd., Vale Inco Ltd., Votorantim Metais Niquel SA, and Yantai Cash Industrial Co. Ltd. Even before the cobalt contract was launched, some companies were planning to use LME cobalt prices as reference prices in their sales contracts. In general, trends in LME cobalt prices were similar to trends in spot prices reported by Metal Bulletin, although beginning in mid-September, changes in LME price trends usually preceded those of Metal Bulletin. Yearend LME inventory levels are listed in table 1 (London Metal Exchange Ltd., The, 2010; Metal Bulletin, 2010b; Taarland, 2011, p. 9).

Financial services companies such as Credit Suisse Group and Standard Bank offered financial products based on cobalt, including hedging and speculation products and option and swap contracts (Southgate, 2010).

Foreign Trade

Net import reliance as a percentage of apparent consumption is used to measure the adequacy of current domestic production to meet U.S. demand. Net import reliance was defined as imports minus exports plus adjustments for Government and industry stock changes. Releases from stocks, including shipments from the NDS, were counted as part of import reliance, regardless of whether they were originally imported or produced in the United States. In 2010, net import reliance as a percentage of apparent consumption was 81%. Because there was no measurable U.S. primary cobalt production in 2010, this indicates that 81% of U.S. cobalt supply was from imports and stock releases of primary cobalt and 19% was from domestic or imported scrap.

In 2010, on the basis of contained cobalt, the United States imported 44% more cobalt than it did in 2009 (tables 4, 5). Ten countries supplied 87% of U.S. imports. China was the leading supplier, followed by Russia, Norway, Finland, Australia, Belgium, Zambia, Congo (Kinshasa), Canada, and the United Kingdom.

The United States imported 202 t, gross weight, of unwrought cobalt alloys valued at $8.9 million. Most of these materials were from Canada (48%) and the United Kingdom (47%). The United States imported 819 t, gross weight, of cobalt waste and scrap valued at $12.9 million. Seven countries supplied nearly 90% of this material—the United Kingdom (32%), Ireland (28%), Japan (11%), Germany (7%), France and Tunisia (4% each), and Canada (3%). The United States also imported 202 t, gross weight, of wrought cobalt and cobalt articles valued at $19.1 million. The leading suppliers of these materials were the United Kingdom (30%), Germany (20%), Canada (15%), Belgium and France (12% each), and Japan (6%).

U.S. exports of unwrought cobalt and cobalt contained in chemicals increased by 8% compared with those of 2009. As listed in table 6, the leading destinations for these exports were Ireland, France, the United Kingdom, Canada, Belgium, Germany, and Japan. The United States also exported 1,680 t, gross weight, of wrought metal and cobalt articles valued at $96.2 million.

World Review

Cobalt was produced as a byproduct of copper, nickel, and other metals, and as a primary product. Primary cobalt production included Moroccan mine and refinery production, the artisanal mining of the mineral heterogenite in Congo (Kinshasa), and the recovery of cobalt from previously stockpiled intermediate materials [for example, slags in Congo (Kinshasa) and Zambia], which were processed primarily to recover cobalt.

Refinery capacity by country is listed in table 7. Plants that processed refined cobalt, used secondary materials (scrap) as their main source of feed, or produced a cobalt product that required further refining were not included.

The European Commission reported the results of a study of 41 economically important minerals and metals. Cobalt was 1 of 14 raw materials identified as critical for European Union supply within 10 years, based on their high economic importance and high risk of supply shortage relative to other materials in the study. For cobalt, the high risk of supply shortage was because a large share of worldwide production comes from Congo (Kinshasa). This was compounded by limited options for substitution (European Commission, 2010, p. 5–6, 23, 36).

The following review by country focuses on operations in production during 2010. Expansions to those operations, operation restarts, and greenfield projects that were forecast to begin producing between 2011 and 2015 are listed in table 8.

Australia.—The Yabulu nickel-cobalt refinery in Townsville, Queensland (owned by Australian businessman Clive Palmer and operated by Queensland Nickel Pty. Ltd.) produced 2,141 t of refined cobalt as cobalt oxide hydroxide; 26% more than the 1,700 t produced in 2009. The increase was attributed to the higher cobalt content of ore processed and Queensland Nickel's efforts to increase the plant's cobalt recovery rate from its traditional level of about 50%. The refinery processed lateritic ore imported from Indonesia, New Caledonia, and the Philippines. Queensland Nickel was interested in obtaining nickel-cobalt intermediate feed for the production line that had been built to process nickel-cobalt mixed hydroxide from the Ravensthorpe operation prior to its closure and sale to First Quantum Minerals Ltd. (Morgan, 2010; Cobalt Development Institute, 2011).

BHP Billiton's Nickel West operations in Western Australia comprised nickel sulfide mines; concentrators, which processed ores mined by BHP Billiton and those from other companies; the Kalgoorlie smelter, where nickel matte was produced; and the Kwinana nickel refinery, which produced cobalt in intermediate nickel-cobalt mixed sulfide.

The Murrin Murrin Nickel Cobalt Joint Venture (60% Minara Resources Ltd. and 40% Glencore) produced 1,976 t of cobalt as metal powder and briquettes from its nickel-cobalt laterite mining and pressure-acid leaching operation near Leonora, Western Australia, 16% less than the 2,350 t produced in 2009. The decrease was attributed to plant shutdowns for statutory maintenance and to repair an autoclave pipeline failure. Minara's demonstration plant for recovering nickel and cobalt by heap-leaching stockpiled ore-reject material provided 83 t of the cobalt produced. In addition to feed from its own operations, Minara also processed ore from Western Areas NL's Spotted Quoll Mine in 2010 (Minara Resources Ltd., 2011a, p. 16, 18–19; b, p. 24).

OJSC MMC Norilsk Nickel's Western Australian nickel operations remained on care-and-maintenance status throughout the year. In December, Norilsk announced that it planned to restart production from the Lake Johnston nickel sulfide mine and mill during the first half of 2011 (OJSC MMC Norilsk Nickel, 2010, p. 36; 2011, p. 69–70).

Panoramic Resources Ltd. produced concentrates containing 364 t of cobalt (420 t in 2009) from its Savannah underground nickel-copper sulfide mine operation in Western Australia. The concentrates were shipped to Jinchuan's operations in China under a long-term offtake agreement (Panoramic Resources Ltd., 2010, p. 5; 2011, p. 6).

Xstrata Nickel Australasia produced 245 t of cobalt in nickel sulfide concentrates from the Cosmos and Sinclair operations in Western Australia, compared with 459 t in 2009. All the concentrates were sent to Xstrata Nickel's Sudbury smelter in Ontario, Canada (Xstrata plc, 2011b).

Belgium.—According to the Cobalt Development Institute (2011), Umicore's 2010 cobalt refinery production increased to 2,600 t from 2,150 t produced in 2009. The company attributed the increase to greater availability of scrap resulting from higher prices and higher levels of downstream production. Umicore converted cobalt metal, residues, and other cobalt-bearing materials into a wide range of cobalt specialty products, including metal powders, hydroxides, oxides, salts, and compounds. Umicore refined cobalt at plants in Olen, Belgium, and Ganzhou, China. The company processed cobalt at plants in Arab, AL, in the United States; Bruges, Belgium; Fort Saskatchewan, Alberta, Canada; Jiangmen and Shanghai, China; and Cheonan, Republic of Korea. Umicore was expanding the production capability of its plants in Cheonan and Jiangmen to include nickel-manganese-cobalt cathode materials for lithium-ion batteries, began construction on a new battery material plant in Kobe, Japan, and was building an industrial-scale recycling facility for spent rechargeable batteries and battery manufacturing scrap in Hoboken, Belgium (n.v. Umicore, s.a., 2011, p. 5, 26, 70).

Botswana.—Tati Nickel Mining Co. Pty. Ltd. (a Norilsk subsidiary) mined the Phoenix open pit and produced nickel-copper sulfide concentrates, which were toll-smelted by BCL Ltd. in Botswana. BCL also smelted concentrate from its Selebi-Phikwe operation in Botswana and the Nkomati Mine in South Africa. Matte produced by BCL was refined by RioZim Ltd. in Zimbabwe and Xstrata Nickel in Norway (Botswana Gazette, 2009; OJSC MMC Norilsk Nickel, 2010, p. 37).

Brazil.—Votorantim produced cobalt cathode at its refinery in Sao Miguel Paulista, Sao Paulo State, from lateritic nickel-cobalt ore mined from Niquelandia, Goias State and nickel sulfide concentrate from Mirabela Nickel Ltd. The company also produced nickel matte, primarily from sulfide ores mined and smelted at Fortaleza de Minas, Minas Gerais State.

Mirabela Nickel continued to ramp up production from its Santa Rita open pit nickel sulfide mine and concentrator in Bahia State, and by yearend, produced 179 t of cobalt in concentrate (14 t in 2009). All concentrate produced from Santa Rita was committed via offtake agreements with Votorantim (50%) and Norilsk (50%) (Mirabela Nickel Ltd., 2011).

Canada.—Vale S.A. (formerly Vale Inco Ltd.) produced 1,066 t of cobalt in 2010, 32% less than the 1,575 t produced in 2009. Production during the past 2 years was reduced by labor strikes at its operations in Sudbury from July 2009 to July 2010 and Voisey's Bay from August 2009 through January 2011. Vale reported production in the form of cathode, 438 t, from its Port Colborne, Ontario, refinery; cobalt hydrate, 499 t, from its Thompson, Manitoba, refinery; and cobalt contained in unrefined products such as nickel concentrates, 129 t. Vale's cobalt originated from nickel sulfide ores from company mines at Sudbury, Ontario; Thompson, Manitoba; and Voisey's Bay in northeastern Labrador; and purchased feedstocks. Vale reported the following distribution of sources for its cobalt production: Voisey's Bay, 524 t (971 t in 2009); Ontario, 302 t (359 t in 2009); Manitoba, 189 t (181 t in 2009); and external sources, 51 t (64 t in 2009). Concentrates from Voisey's Bay are being smelted and refined at Sudbury and Thompson until the Long-Harbour refinery is operational (table 8). Vale planned to phase out smelting and refining at Thompson by 2015 (Vale S.A., 2011, p. 35–36, 44–45).

Xstrata Nickel produced 341 t of cobalt in concentrates from mines at Sudbury (277 t in 2009) and 567 t of cobalt in concentrate from its Raglan Mine in Quebec (586 t in 2009). Nickel-copper matte containing 2,634 t of cobalt was produced at the company's Sudbury smelter (2,476 t in 2009); this was refined at Xstrata's Nikkelverk refinery in Norway. Some of the cobalt in the matte originated from ores produced at company mines in Australia and Canada and some originated from custom feed materials, which were primarily nickel concentrates, nickel-copper-cobalt secondary materials (scrap), and copper-cobalt white alloy purchased from Glencore. Custom feed from mining operations included nickel sulfide ores containing approximately 50 t of cobalt from URSA Major Minerals Inc.'s Shakespeare Mine in Ontario, nickel sulfide concentrates produced by Crowflight Minerals Inc.'s Bucko Lake nickel mine in the Thompson Nickel Belt of Manitoba and Liberty Mines Inc. in Ontario, and a copper-nickel-PGM-precious metals concentrate containing approximately 4 t of cobalt from North American Palladium Ltd.'s Lac des Iles Mine in Northern Ontario. Secondary custom feed materials included battery-manufacturing scrap, high-grade slags, metal residues, smelter byproducts, spent batteries and catalysts, superalloy and other alloy scrap, and other secondary materials (Tollinsky, 2008; Xstrata Nickel, 2008, p. 9–11, 21; North American Palladium Ltd., 2011, p. 15; URSA Major Minerals Inc., 2011; Xstrata plc, 2011a, p. 205; 2011b).

The Fort Saskatchewan refinery of the joint venture of Sherritt International Corp. and General Nickel Co. S.A. produced 3,706 t of cobalt as metal powder and briquettes in 2010, slightly less than the 3,721 t produced in 2009. Approximately 96% of the cobalt was from nickel-cobalt mixed sulfides from the joint venture's operations at Moa Bay, Cuba; the remainder was from purchased feed materials. During 2010, the joint-venture partners reviewed alternative strategies for completing the phase 2 expansion of the refinery, which was suspended in 2008. As a result of a United States embargo on imports of products originating from Cuba, cobalt and nickel produced by Sherritt cannot be sold to customers in the United States (Sherritt International Corp., 2011, p. 7–8, 10).

First Nickel's Lockerby Mine was on care-and-maintenance status all year. In 2010, Liberty Mines produced nickel sulfide ore from its Redstone and McWatters Mines near Timmins, Ontario, which was processed at the company's Redstone Mill. The resulting concentrates, containing 17 t of cobalt in 2010, were shipped to Xstrata Nickel's smelter in Sudbury (Liberty Mines Inc., 2011, p. 1–4).

China.—China's total production of refined cobalt was nearly 34,000 t, which made it the world's leading producer. In 2010, only a small portion of China's cobalt production originated from domestic mines or recycled scrap. Most of the production was from imported ores, concentrates, and semirefined materials, the majority which was sourced from Congo (Kinshasa). CRU International Ltd. (London, United Kingdom) estimated that China imported 35,300 t of cobalt contained in ores, concentrates, and semirefined materials in 2010, up from 24,900 t in 2009. China's imports of cobalt ores and concentrates increased by 11% and imports of semirefined materials more than doubled in 2010 compared with those of 2009 (Collignon, 2011, p. 7–8; CRU International Ltd., 2011, p. 7; Xu, 2011, p. 5, 7).

Numerous companies refined and (or) processed cobalt in China. The leading four refiners were Jinchuan, Zhejiang Huayou Cobalt Nickel Materials Co., Ltd., Zhejiang Galico Cobalt & Nickel Material Co., Ltd., and Ganzhou Yi Hao Umicore Industries, listed in descending order of 2010 estimated cobalt production. Jinchuan produced cobalt as cathode and other products from its refinery at Jinchang, Gansu Province. Some of Jinchuan's cobalt production was from domestic nickel-copper-cobalt sulfide ores mined and refined at Jinchang and some was from other cobalt or nickel feeds. Jinchuan's other feeds included cobalt intermediates (chemical compounds), which were either imported or produced in China from imported concentrates; nickel-copper concentrates from Australia, Spain, and Zambia; nickel concentrates from Australia; and nickel matte from BHP Billiton (Metal Bulletin Daily, 2009; CRU International Ltd., 2011, p. 4, 6).

Congo (Kinshasa).—Congo (Kinshasa) was the world's leading producer of mined cobalt. Some of the country's cobalt mine production was from copper-cobalt ores mined by traditional methods, and some was gathered by tens of thousands of artisanal miners hand-picking cobalt-rich ores. Some of Congo (Kinshasa)'s ores and concentrates were exported, some were processed to semirefined materials such as cobalt carbonate, cobalt hydroxide, or cobalt-bearing alloys, and some were refined to cobalt metal. China was the leading destination for Congo (Kinshasa)'s cobalt exports. As discussed in the "China" section of this report, exports of cobalt materials to China increased in 2010 compared with those of 2009. In an effort to encourage refining of copper and cobalt materials in-country, the Government of Congo (Kinshasa) prohibited the export of unrefined minerals. The governor of Katanga Province, where copper and cobalt were mined, then signed a law that allowed companies to export concentrates if they paid a tax of $60 per metric ton (Kavanagh, 2010).

The Government of Congo (Kinshasa) completed its review of mining contracts signed between private companies and the Government or Government-owned companies. The review, which began in 2007, was intended to evaluate whether each contract gave a fair share of its revenues to the country and to determine whether it should be maintained, renegotiated, or terminated. The contract for the Kolwezi Tailings project, which was being developed by First Quantum, was terminated in early 2010. As a result, First Quantum and the project's other contributing partners commenced international arbitration on the matter (First Quantum Minerals Ltd., 2011, p. 32–33).

Korea Resources Corp. and Korea Water Resources Corp. signed an agreement for two ventures with Congolese mining company S.A. Groupe George Forrest and international investment firm Alfonso Rowemberg Korea Ltd. Under the agreement, the South Korean companies were to assist in dam building, water system, and other infrastructure projects including a cobalt processing plant, in exchange for supplies of copper, cobalt, and uranium (Chung-un, 2010).

La Générale des Carrières et des Mines (Gécamines) produced 745 t of refined cobalt, compared with 415 t produced in 2009 (Cobalt Development Institute, 2011).

Kamoto Copper Co. SARL (KCC, a joint venture of Katanga Mining Ltd. and Gécamines) increased its production of cobalt cathode to 3,437 t from 2,534 t in 2009. The company's Luilu refinery processed concentrates produced at the Kamoto concentrator from ore extracted from the Kamoto underground mine, T17 open pit, and the large Kamoto-East Olivera Virgule (KOV) open pit mine, which began commercial production in 2010. During the year, the company continued to make improvements at the mines, concentrator, and refinery, and announced that it planned additional increases in capacity (table 8). Glencore had an offtake agreement for all of KCC's copper and cobalt output; Katanga Mining reported that concentrate was sold to Mopani Copper Mines in Zambia in 2010 (Katanga Mining Ltd., 2011, p. 2–4, 26).

In late 2009, Eurasian Natural Resources Corp. PLC (ENRC) acquired Central African Mining & Exploration Company plc (CAMEC), including CAMEC's 70% share in Boss Mining Sprl; Gécamines held the remaining 30%. In 2010, ENRC increased its African copper-cobalt assets by acquiring Congo Cobalt Corporation Sprl and Société Minière de Kabolela et de Kipese in Congo (Kinshasa), forming a joint venture with Camrose Resources Ltd. in Congo (Kinshasa), and acquiring a majority interest in Chambishi Metals plc in Zambia. Boss Mining mined copper-cobalt ore from open pits in the Mukondo Mountain, Disele, and Kabolela North deposits and produced concentrates containing 8,273 t of cobalt, compared with 6,697 t in 2009. By yearend, Boss Mining had completed construction of a new cobalt solvent extraction–electrowinning (SX–EW) plant at Luita and expected to begin producing cobalt metal in 2011 (Eurasian Natural Resources Corp. PLC, 2011a, p. 19, 40, 46; b, p. 17).

Gécamines and L'Enterprise Générale Malta Forrest S.P.R.L. produced 2,545 t of cobalt in copper-cobalt concentrate from the Luiswishi Mine and Kipushi concentrator. Production in 2009 was only 437 t of cobalt in concentrate because of a temporary suspension of operations that began in late 2008 in response to low demand and prices (Harrison, 2008; La Générale des Carrières et des Mines, undated).

The Big Hill smelter at Lubumbashi [operated as a joint venture between Gécamines, OM Group, Inc. (OMG), and Groupe George Forrest] processed stockpiled slag to produce alliage blanc, an alloy of cobalt and copper, which was refined at OMG's Kokkola refinery in Finland. In 2010, the smelter produced 4,232 t of cobalt contained in alliage blanc, compared with 4,590 t in 2009 (George Forrest International S.A., 2010; La Générale des Carrières et des Mines, undated).

Freeport-McMoRan Copper & Gold Inc. (FCX) produced 9,302 t of cobalt in hydroxide from its Tenke Fungurume project, compared with approximately 1,360 t (3 million pounds) in 2009. The project, between the towns of Kolwezi and Likasi, comprised open pit mining of sediment-hosted copper-cobalt ore, recovering the metals by agitation leaching, and SX–EW to produce copper cathode and cobalt hydroxide. FCX was planning a second phase of the project, which would optimize production from the current plant and expand its capacity. By yearend, the Governement of Congo (Kinshasa) had completed its review of Tenke Fungurume Mining S.A.R.L.'s mining contracts. As part of the review, the contracts were amended to increase Gecamines ownership in Tenke Fungurume to 20%. FCX's ownership was reduced to 56% and Lundin Mining Corp.'s to 24% (Freeport-McMoRan Copper & Gold Inc., 2011, p. 43; La Générale des Carrières et des Mines, undated).

Chemaf SPRL mined copper-cobalt oxide ores from the Etoile open pit mine and processed run-of-mine ore, concentrates, and purchased ore at its SX–EW plant at Usoke in Lubumbashi. The plant produced 2,744 t of cobalt contained in carbonate, slightly less than the 2,780 t produced in 2009 (Shalina Resources Ltd., 2010; undated).

Metorex Ltd.'s Ruashi operation north of Lubumbashi comprised mining copper-cobalt oxide ores from open pits and then milling and processing the ore in the Ruashi phase 2 SX–EW refinery. In 2010, production of cobalt in carbonate increased to 3,580 t from 2,198 t in 2009. Gécamines had a 25% interest in the Ruashi operation (Metorex Ltd., 2011, p. 36–37).

Société Minière du Katanga sprl (Somika) mined and beneficiated copper-cobalt ore and refined the concentrate at its hydrometallurgical copper refinery in Lubumbashi. The refinery had the capacity to produce 2,160 t/yr of cobalt hydroxide (Société Minière du Katanga sprl, undated).

CuCo Resources Ltd. (Toronto, Ontario, Canada) commissioned a cobalt beneficiation plant at its Kisanfu property in the Kolwezi mining district. The commercial plant, which was expected to produce 3,000 t of cobalt in concentrates during the second half of 2011, was an expansion of a small pilot plant built by the company. Concentrates produced at Kisanfu were to be sold to Somika for processing (Metal Bulletin, 2010a; CuCo Resources Ltd., 2011).

Cuba.—Moa Nickel S.A. (part of the 50–50 joint venture between Sherritt and General Nickel) mined nickel-cobalt laterites at Moa Bay, Holguin Province, and produced mixed sulfides, which were sent to the joint venture's Fort Saskatchewan refinery in

Canada. In 2010, the mixed sulfides contained a record 37,745 t of nickel and cobalt, slightly more than the 37,328 t produced in 2009. The increase in production was mainly attributed to stable operating conditions at the recently expanded Moa plant. During the year, the joint-venture partners reviewed alternative strategies for the completion of the phase 2 expansion of the plant, which was suspended in 2008 (Sherritt International Corp., 2011, p. 7–8, 10).

The Ernesto Che Guevara and Rene Ramos Latour Mining and Metallurgical Combines also mined nickel-cobalt laterites and produced mixed nickel-cobalt sulfides in Holguin Province. Nickel and cobalt of Cuban origin cannot be imported into the United States because of a United States embargo on imports from Cuba.

Finland.—OMG's production of refined cobalt, as metal powders, briquettes, oxides, and compounds, was 5% higher than that of 2009. The company's Kokkola Chemicals Oy refinery processed raw materials sourced primarily from Congo (Kinshasa), Finland, and Russia. Most of the feed was alliage blanc from the Big Hill smelter in Congo (Kinshasa), crude cobalt hydroxide from Norilsk's Monchegorsk nickel refinery in Russia, and cobalt sulfate solution from Norilsk's Harjavalta nickel refinery in Finland. OMG also refined materials from other sources, such as ores and concentrates, sulfides, metallic feeds, and secondary materials (scrap) (OM Group, Inc., 2011, p. 6–7, 33; Thomson Reuters, 2011, p. 12).

Talvivaara Mining Co. Plc continued to ramp up and optimize production from its polymetallic sulfide mine and bioheap-leaching operation in Sotkamo in central Finland. As part of its plan to increase the operation's production capacity, the company added a second production line to its metal recovery plant (table 8). During the year, the company sold nickel-cobalt sulfide containing 94 t of cobalt to Norilsk for processing at Harjavalta (Talvivaara Mining Co. Plc, 2011, p. 5–7).

Belvedere Resources Ltd. purchased the Hitura nickel-copper sulfide mine from administrators and restarted production. Nickel-copper concentrates containing an estimated 37 t of cobalt were sold to Jinchuan in 2010 (Belvedere Resources Ltd., 2011, p. 1–2).

France.—The Eramet Group's production of cobalt chloride from its refinery at Sandouville was 18% less than that produced in 2009. Feed for the refinery was nickel matte imported from Eramet subsidiary Le Nickel SLN's Doniambo smelter in New Caledonia (Cobalt Development Institute, 2011).

India.—According to an estimate by the Cobalt Development Institute (2011), India's cobalt production increased by 19% from that of 2009. Nicomet Industries Ltd. and Rubamin Ltd. were India's leading cobalt producers.

Indonesia.—PT International Nickel Indonesia Tbk (PT Inco) produced nickel matte from lateritic ores at its integrated mining and smelting operation near Sorowako on Sulawesi Island. Cobalt contained in matte deliveries increased to 1,196 t from 891 t in 2009. PT Inco sold its entire matte production to Vale (80%) and Sumitomo Metal Mining Co., Ltd. (20%) under long-term contracts (PT International Nickel Indonesia Tbk, 2011, p. 175).

PT Antam Tbk exported lateritic nickel-cobalt ore to Queensland Nickel's Yabulu refinery for processing (CRU International Ltd., 2011, p. 4).

Japan.—Sumitomo's production of electrolytic cobalt at its Niihama nickel refinery increased by 45% from that of 2009, as a result of an increase in nickel-cobalt mixed sulfide feed from the Coral Bay Nickel Corp. plant in the Philippines. The refinery also processed nickel matte from BHP Billiton's Nickel West operations and PT Inco in Indonesia. Sumitomo planned to increase Niihama's production capacity to accommodate the nickel-cobalt mixed sulfide feed that would be generated from its Taganito project in the Philippines (table 8) (Cobalt Development Institute, 2011; CRU International Ltd., 2011, p. 4; Sumitomo Metal Mining Co., Ltd., 2011).

Morocco.—Cie. de Tifnout Tighanimine (CTT) produced cobalt hydroxide at its processing plant at Bouazzer and cobalt cathode and oxide at its Guemassa hydrometallurgical refinery north of Marrakech. CTT's cobalt production was from domestic cobalt-arsenic deposits and heterogenite imported from Congo (Kinshasa).

New Caledonia.—Vale nearly completed the commissioning of its Vale New Caledonia project in the southern tip of New Caledonia's main island. The project, which was originally called Goro, comprised a nickel-cobalt laterite mine, high pressure acid leaching processing plant, and refinery. Initial production was in the form of an intermediate nickel-cobalt hydroxide cake, which was sold to other companies for refining. Vale expected to ramp up production during a 3-year period to reach the nominal production capacity of 60,000 t/yr of nickel contained in nickel oxide and 4,600 t/yr of cobalt contained in cobalt carbonate. Vale's partners in the project were Sumitomo Metal Mining, Mitsui & Co., Ltd., and Société de Participation Minière du Sud Calédonien S.A.S., listed in order of percent share (Vale S.A., 2011, p. 37).

Lateritic nickel-cobalt ore was exported to Queensland Nickel's Yabulu refinery for processing. Nickel matte from Le Nickel SLN's Doniambo smelter was sent to Eramet's refinery in Sandouville, France, where nickel products and cobalt chloride were produced.

Norway.—Xstrata Nickel's production of cobalt cathode at its Nikkelverk refinery was 9% less than that of 2009. The cobalt originated from Xstrata Nickel mines in Australia and Canada, recycled materials, and custom feeds, which included matte from Botswana processed under a long-term agreement with BCL, and copper-cobalt white alloy purchased from Glencore. The white alloy agreement included a metal return component for cobalt. In 2010, Xstrata purchased 15 t of cobalt in white alloy (250 t in 2009) and returned 64 t of cobalt metal (297 t in 2009). Glencore was the sole distributor of Xstrata's cobalt. In 2010, Xstrata sold 3,104 t of cobalt to Glencore (3,066 t in 2009) (CRU International Ltd., 2011, p. 4; Xstrata plc, 2011a, p. 205; b).

Philippines.—Coral Bay Nickel (a joint venture between Sumitomo, Mitsui & Co., Ltd., Sojitz Corp., and Rio Tuba Nickel Mining Corp., listed in order of percent share) produced nickel-cobalt mixed sulfide from its high-pressure acid-leaching operation at the Rio Tuba nickel laterite mine on Palawan Island. The mixed sulfide was refined by Sumitomo in Japan.

Russia.—Norilsk conducted nickel-copper sulfide mining, ore beneficiation, concentrate smelting, and metal refining on the Kola and Taimyr Peninsulas. Cobalt from ores mined on the Taimyr Peninsula was refined to metal at the company's nickel plant at Norilsk. According to the Cobalt Development Institute (2011), the company produced 2,460 t of refined cobalt, 5% more than the 2,352 t produced in 2009. At Norilsk's nickel plant in Monchegorsk on the Kola Peninsula, high-grade matte produced from both regions was refined. The intermediate cobalt hydroxide produced from the matte was sent to OMG's operations in Finland under a 5-year supply agreement that began in 2007. Under this agreement, Norilsk was to supply OMG with up to 2,500 t/yr cobalt metal, up to 2,500 t/yr of cobalt contained in cobalt hydroxide, and up to 1,500 t/yr of cobalt contained in cobalt sulfate solution. In 2010, Giproproekt Institute began to develop detailed designs for the production of electrolytic cobalt at Monchegorsk (OJSC MMC Norilsk Nickel, 2011, p. 7–9, 23; OM Group, Inc., 2011, p. 6; Thomson Reuters, 2011, p. 12).

South Africa.—The Nkomati nickel sulfide mine (a joint venture of African Rainbow Minerals Ltd. and Norilsk) produced 667 t of cobalt in 2010, two times the 333 t produced in 2009. The increase resulted from progress on the Nkomati large-scale expansion project. At full steady-state production, forecast for 2013, the mine was expected to produce 1,000 t/yr of cobalt in concentrates (African Rainbow Minerals Ltd., undated; 2011a, p. 19–20; 2011b, p. 63).

Cobalt was also produced as a byproduct from some of South Africa's PGM operations. Two companies produced refined cobalt. Rustenburg Base Metals Refiners (Proprietary) Ltd. (a subsidiary of Anglo American plc) produced cobalt sulfate at its base-metal refinery near Rustenburg, Northwest Province. The company was increasing the nickel capacity of the refinery to 33,000 t/yr from 21,500 t/yr; an equivalent increase in cobalt capacity was expected (table 8). Impala Platinum Ltd. produced cobalt metal powder at its base-metals refinery near Springs, Gauteng Province. Some of the cobalt produced by Impala was recovered from concentrates produced at the Mimosa platinum mine in Zimbabwe. Two other platinum producers—Lonmin plc and Northam Platinum Ltd.—operated base-metal refineries and produced semirefined nickel sulfate containing cobalt.

Spain.—Lundin Mining Corp.'s Aguablanca open pit nickel sulfide mine and processing plant in Badajoz Province produced nickel-copper concentrate containing an estimated 150 t of cobalt, which it sold to Glencore under a long-term sales agreement. Operations at Aguablanca were suspended at yearend following a significant slope failure that affected the main access ramp to the pit (Lundin Mining Corp., 2010).

Uganda.—Kasese Cobalt Co. Ltd. produced cobalt cathode from stockpiled pyrite concentrates using a bacterial leaching-SX-EW process at its cobalt refinery in southwestern Uganda. At current production rates, the stockpile was expected to be exhausted in 2013. The company hoped that production would restart at the nearby Kilembe Mine, so that more feed would become available for its refinery (Metal Bulletin, 2009).

Zambia.—Mopani Copper Mines produced 1,092 t of cobalt metal at its Nkana cobalt refinery, a decrease from the 1,271 t produced in 2009 and 1,458 t produced in 2008. Approximately 73% of the cobalt originated from company sources, mainly the Nkana underground copper-cobalt mine; the remaining 27% originated from third party sources (Glencore International plc, 2011a, p. 12; b, p. 72).

ENRC completed its acquisition of Enya Holdings BV, which held a 90% interest in Chambishi Metals plc. The Chambishi refinery produced 3,265 t of cobalt metal, a significant increase from the 235 t produced in 2009. Feed for the refinery was mined in Congo (Kinshasa), and included carbonate from Luita and hydroxide from Tenke Fungurume (Platts Metals Week, 2010; Cobalt Development Institute, 2011; Eurasian Natural Resources Corp. PLC, 2011a, p. 19, 31, 40).

Konkola Copper Mines Plc (KCM) mined copper ores from its Nchanga and Konkola operations. The company's main source of cobalt was its Nchanga open pit. Cobalt in concentrate was processed to a copper-iron-cobalt alloy at the company's Nchanga copper smelter in Chingola. KCM planned to expand the cobalt production capacity of the smelter (table 8) (Finfacts, 2010; Vedanta Resources plc, 2010, p. 15).

NFC Africa Mining plc [85% China Nonferrous Metal Mining Group Co. Ltd. (CNMC) and 15% ZCCM Investments Holdings Plc.] made investments at its Luanshya Copper Mine operation, which included upgrading the concentrator and installing a new hoisting system at the Baluba copper-cobalt mine (Chulu, 2010; Platts Metals Week, 2011).

Chambishi Copper Smelter Ltd. (a joint venture between CNMC and Yunnan Copper Industry Group Co. Ltd.) smelted concentrates from NFC Africa Mining's Chambishi Mine and other Zambian copper mines. The smelter had the capacity to produce 150,000 t/yr of copper and 2,800 t/yr of cobalt. Equinox Minerals Ltd. had an offtake agreement with Chambishi Copper Smelter to process copper concentrates from its Lumwana Mine. Equinox also sent Lumwana concentrates to KCM's Nchanga smelter for processing (Interfax China Ltd., 2008; Equinox Minerals Ltd., 2011, p. 18).

Metorex produced 42 t of cobalt in cobalt carbonate at its Sable Zinc copper electrowinning plant near Kabwe, compared with 39 t produced in 2009. The low cobalt production levels in recent years were attributed to the low cobalt grades of the Zambian copper concentrates processed by the plant (Metorex Ltd., 2011, p. 40–41).

Albidon Ltd. restarted concentrate production at its Munali nickel mine in southern Zambia. Shipments of nickel-copper-cobalt-PGM sulfide concentrate from Munali to Jinchuan resumed in April (Albidon Ltd., 2010).

Zimbabwe.—Bindura Nickel Corp.'s Shangani and Trojan nickel sulfide mines, smelter, and refinery remained on care-and-maintenance status throughout the year. The company developed plans to resume production from the Trojan mine and concentrator. Nickel concentrates would be sold for further processing until the smelter and refinery were restarted. Cobalt hydroxide was one of the products from the company's refinery (Mwana Africa PLC, 2010, p. 11, 13). Aquarius Platinum Ltd. produced 79 t of cobalt from its Mimosa platinum mine (74 t in

2009). The concentrates were refined by Impala in South Africa (Aquarius Platinum Ltd., 2010, p. 13; 2011, p. 13).

Outlook

Trends in cobalt consumption closely follow those of global industrial production. The global economic downturn that began in late 2008 resulted in reduced demand for cobalt in 2008 and 2009, affecting all major end-use sectors. As global economic conditions improved in 2009 and 2010, cobalt consumption increased. In 2010, there was a firm recovery in superalloy orders, particularly from the aerospace sector, and growth in cobalt consumption for superalloy production was forecast to rise by about 10% per year during 2011–13. In the rechargeable battery market, strong growth during the first half of 2010 was followed by a slowdown during the second half owing to a weakening of consumer confidence and reduced demand for electronic devices. In spite of this, cobalt consumption to make rechargeable batteries was forecast to increase by 14% per year during 2011–13 (Collignon, 2011).

During the first half of 2011, the world production of refined cobalt was estimated to be 13% higher than that of the first half of 2010. In the next few years, global increases in supply from existing producers and new projects are forecast to outpace increases in consumption. In addition, prices during 2010 and early 2011 were still above the estimated marginal cost of cobalt production of approximately $13.50 per pound. Thus, if an oversupply of cobalt were to take place, it could put downward pressure on near term prices (Collignon, 2011; CRU International Ltd., 2011, p. 6).

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TABLE 1

SALIENT COBALT STATISTICS[1]

(Metric tons, cobalt content, unless otherwise specified)

	2006	2007	2008	2009	2010
United States:					
Consumption:					
Reported	9,280	9,320	8,820 [r]	7,470 [r]	8,030
Apparent	11,000	9,630	10,100	7,580 [r]	10,300
Imports for consumption	11,600	10,300	10,700	7,680	11,100
Exports	2,850	3,100	2,850	2,440	2,640
Stocks, December 31:					
Industry[2]	737	620	582	525 [r]	630
London Metal Exchange (LME), U.S. warehouse	XX	XX	XX	XX	23
U.S. Government[3]	1,290	676	473	293	301
Price, metal[4] dollars per pound	17.22	30.55	39.01	17.86	20.85
World:					
Production:					
Mine	70,000 [r]	71,700 [r]	76,400 [r]	72,100 [r]	89,500 [e]
Refinery	53,800	53,300	57,300 [r]	59,700 [r]	76,400
Stocks, December 31, LME[5]	XX	XX	XX	XX	278

[e] Estimated. [r] Revised. XX Not applicable.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Stocks held by cobalt processors and consumers.

[3] Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center). Data for 2006 include material committed for sale pending shipment; data for 2007–10 are uncommitted material only.

[4] Annual average U.S. spot price for minimum 99.8% cobalt cathode reported by Platts Metals Week.

[5] Stocks held in Asia, Europe, and the United States.

TABLE 2

U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE SALES AND SHIPMENTS[1]

(Metric tons, cobalt content)

	2009	2010
Sales:		
Fiscal year[2]	187	6
Calendar year	169	--
Shipments:[3]		
Fiscal year[2]	192	3
Calendar year	180	-8

-- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Twelve-month period ending September 30 of year stated.

[3] Calculated from yearend inventory levels. Yearend data are uncommitted material only. Negative numbers are the result of inventory adjustments.

Source: Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center).

TABLE 3
U.S. REPORTED CONSUMPTION AND STOCKS OF COBALT[1, 2]

(Metric tons, cobalt content)

	2009	2010
Consumption by end use:		
Steels	520 r	550
Superalloys	3,570 r	3,740
Alloys, excludes steels and superalloys:		
Magnetic alloys	287 r	357
Other alloys[3]	331 r	364
Cemented carbides[4]	503	696
Chemical and ceramic uses	2,190	2,260
Miscellaneous and unspecified	63	63
Total	7,470 r	8,030
Consumption by form:		
Chemical compounds, organic and inorganic[5]	2,130	2,180
Metal	3,550 r	3,860
Purchased scrap	1,790	2,000
Total	7,470 r	8,030
Stocks, December 31:[6]		
Chemical compounds, organic and inorganic[5]	171	173
Metal	W	W
Purchased scrap	W	W
Total	525 r	630

rRevised. W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes estimates.

[3] Includes nonferrous alloys, welding materials, and wear-resistant alloys.

[4] Includes diamond tool matrices, cemented and sintered carbides, and cast carbide dies or parts.

[5] Includes oxides.

[6] Stocks held by cobalt processors and consumers.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY FORM[1]

	2009			2010		
	Gross weight (metric tons)	Cobalt content[2] (metric tons)	Value (thousands)	Gross weight (metric tons)	Cobalt content[2] (metric tons)	Value (thousands)
Metal[3]	5,870	5,870	$198,000	8,750	8,750	$350,000
Oxides and hydroxides	1,460	1,050	37,500	2,010	1,450	60,700
Other forms:						
Acetates	168	40	1,220	301	72	2,720
Carbonates	972	447	18,000	686	315	14,400
Chlorides	231	58	2,220	311	78	2,580
Sulfates	760	205	5,900	1,440	388	9,200
Total	9,470	7,680	262,000	13,500	11,100	439,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Estimated from gross weights.

[3] Unwrought cobalt, excluding alloys and waste and scrap.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY[1]

	Metal[2]			Oxides and hydroxides			Other forms[3]			Total		
Country of origin	Gross weight (metric tons)	Cobalt content[4] (metric tons)	Value[5] (thousands)	Gross weight (metric tons)	Cobalt content[4] (metric tons)	Value[5] (thousands)	Gross weight (metric tons)	Cobalt content[4] (metric tons)	Value[5] (thousands)	Gross weight (metric tons)	Cobalt content[4] (metric tons)	Value[5] (thousands)
2009:												
Australia	380	380	$11,600	--	--	--	--	--	--	380	380	$11,600
Belgium	99	99	4,560	531	382	$16,100	69	24	$850	699	505	21,500
Brazil	172	172	5,280	--	--	--	7	2	60	179	173	5,340
Canada	246	246	7,820	471	339	8,140	2	(6)	5	719	586	16,000
China	1,360	1,360	47,800	128	92	3,590	433	150	5,570	1,920	1,600	57,000
Congo (Kinshasa)	101	101	3,170	--	--	--	--	--	--	101	101	3,170
Finland	175	175	7,340	151	108	4,020	1,180	438	16,200	1,510	721	27,600
France	18	18	968	--	--	--	1	(6)	23	19	18	992
Germany	14	14	1,010	4	3	336	--	--	--	18	16	1,340
Hong Kong	--	--	--	14	10	335	--	--	--	14	10	335
India	2	2	47	--	--	--	206	56	1,620	208	58	1,670
Japan	273	273	10,700	3	2	176	45	12	374	321	287	11,300
Morocco	247	247	7,550	--	--	--	--	--	--	247	247	7,550
Norway	1,650	1,650	52,300	--	--	--	--	--	--	1,650	1,650	52,300
Russia	851	851	28,500	--	--	--	--	--	--	851	851	28,500
South Africa	26	26	847	1	1	29	--	--	--	27	26	876
Taiwan	5	5	99	--	--	--	40	9	91	44	14	190
Uganda	30	30	968	--	--	--	--	--	--	30	30	968
United Kingdom	42	42	1,500	149	108	4,580	140	54	2,360	331	204	8,440
Zambia	183	183	5,080	--	--	--	--	--	--	183	183	5,080
Other	7	7	331	9	6	226	8	4	173	24	17	730
Total	5,870	5,870	198,000	1,460	1,050	37,500	2,130	751	27,300	9,470	7,680	262,000
2010:												
Australia	711	711	28,000	--	--	--	--	--	--	711	711	28,000
Belgium	198	198	7,310	543	391	19,400	43	11	364	784	601	27,100
Brazil	166	166	6,930	--	--	--	20	6	245	186	172	7,180
Canada	141	141	6,700	415	299	9,160	--	--	--	556	440	15,900
China	2,330	2,330	93,400	355	255	9,850	728	209	3,640	3,410	2,790	107,000
Congo (Kinshasa)	465	465	14,300	--	--	--	--	--	--	465	465	14,300
Finland	276	276	14,600	242	174	7,820	1,150	403	16,500	1,660	854	38,900
France	23	23	1,490	--	--	--	74	18	393	97	42	1,880
Germany	15	15	857	7	5	649	(6)	(6)	3	22	20	1,510
India	61	61	2,560	--	--	--	382	103	3,350	443	164	5,910
Japan	272	272	13,000	4	3	147	--	--	--	276	274	13,200
Morocco	235	235	9,160	--	--	--	--	--	--	235	235	9,160

See footnotes at end of table.

TABLE 5—Continued
U.S. IMPORTS FOR CONSUMPTION OF COBALT, BY COUNTRY[1]

	Metal[2]			Oxides and hydroxides			Other forms[3]			Total		
Country of origin	Gross weight (metric tons)	Cobalt content[4] (metric tons)	Value[5] (thousands)	Gross weight (metric tons)	Cobalt content[4] (metric tons)	Value[5] (thousands)	Gross weight (metric tons)	Cobalt content[4] (metric tons)	Value[5] (thousands)	Gross weight (metric tons)	Cobalt content[4] (metric tons)	Value[5] (thousands)
Norway	1,240	1,240	$51,500	--	--	--	--	--	--	1,240	1,240	$51,500
Russia	1,520	1,520	56,100	--	--	--	--	--	--	1,520	1,520	56,100
South Africa	321	321	13,400	2	1	$55	--	--	--	323	322	13,400
Sweden	18	18	748	--	--	--	--	--	--	18	18	748
Taiwan	3	3	85	--	--	--	58	16	$576	61	19	660
Uganda	148	148	6,210	--	--	--	--	--	--	148	148	6,210
United Kingdom	17	17	826	446	321	13,600	260	79	3,630	724	418	18,100
Zambia	576	576	22,100	--	--	--	--	--	--	576	576	22,100
Other	10	10	360	--	--	--	27	8	227	38	19	587
Total	8,750	8,750	350,000	2,010	1,450	60,700	2,740	854	28,900	13,500	11,100	439,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Unwrought cobalt, excluding alloys and waste and scrap; includes cobalt cathode and cobalt metal powder; may include intermediate products of cobalt metallurgy.

[3] Includes cobalt acetates, cobalt carbonates, cobalt chlorides, and cobalt sulfates.

[4] Estimated from gross weights.

[5] Customs value.

[6] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6
U.S. EXPORTS OF COBALT IN 2010, BY COUNTRY [1, 2]

	Metal[3]		Oxides and hydroxides		Acetates		Chlorides		Total	
Country of destination	Gross weight (metric tons)	Value[4] (thousands)	Gross weight (metric tons)	Value[4] (thousands)	Gross weight (metric tons)	Value[4] (thousands)	Gross weight (metric tons)	Value[4] (thousands)	Cobalt content[5] (metric tons)	Value[4] (thousands)
Argentina	31	$1,140	--	--	--	--	--	--	31	$1,140
Australia	4	119	1	$20	--	--	--	--	5	138
Austria	14	524	--	--	--	--	--	--	14	524
Belgium	96	1,520	96	497	97	$2,010	--	--	189	4,030
Canada	152	4,120	3	119	188	2,060	2	$23	200	6,320
China	30	963	--	--	8	372	--	--	31	1,330
France	553	17,600	(6)	13	--	--	--	--	553	17,600
Germany	181	9,360	--	--	--	--	(6)	7	181	9,370
Hong Kong	23	397	(6)	6	--	--	--	--	23	403
India	7	281	118	369	20	212	--	--	96	861
Ireland	672	18,700	--	--	--	--	--	--	672	18,700
Italy	12	543	--	--	--	--	--	--	12	543
Japan	171	8,320	--	--	(6)	23	--	--	171	8,350
Korea, Republic of	25	1,540	--	--	--	--	--	--	25	1,540
Malaysia	19	419	--	--	--	--	27	615	26	1,030
Mexico	1	119	38	1,270	92	1,160	(6)	4	50	2,550
Netherlands	46	1,440	(6)	9	--	--	--	--	46	1,450
Singapore	8	577	--	--	--	--	--	--	8	577
Switzerland	10	457	--	--	--	--	--	--	10	457
Taiwan	53	1,660	--	--	2	21	--	--	53	1,680
Tunisia	11	338	--	--	--	--	--	--	11	338
United Arab Emirates	3	300	--	--	--	--	--	--	3	300
United Kingdom	206	3,350	(6)	9	--	--	--	--	206	3,350
Venezuela	2	79	1	40	--	--	--	--	3	119
Other	18	1,180	1	25	--	--	--	--	18	1,200
Total	2,350	75,000	258	2,380	406	5,860	30	650	2,640	83,900

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] In addition to the materials listed, the United States exports cobalt ores and concentrates and wrought cobalt and cobalt articles.

[3] Includes unwrought cobalt, powders, waste and scrap, and mattes and other intermediate products of cobalt metallurgy.

[4] Free alongside ship value.

[5] Estimated from gross weights.

[6] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7
WORLD ANNUAL COBALT REFINERY CAPACITY, DECEMBER 31, 2010[1, 2]

(Metric tons, cobalt content)

Country	Capacity
Australia	6,700
Belgium	1,500
Brazil	1,420
Canada[e]	6,200
China[e]	50,000
Congo (Kinshasa)[e]	10,000
Finland	10,000
France	500
India[e]	2,060
Japan	2,000
Morocco	2,000
Norway	5,200
Russia[e]	6,000
South Africa[e]	850
Uganda	720
Zambia	8,800
Total	114,000

[e] Estimated.

[1] Data are rounded to no more than three significant digits; may not add to total shown.

[2] Includes standby capacity. Refinery products include cobalt metal, metal powders, oxides, and (or) salts.

TABLE 8

COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2015[1,2]

Projected year of first production	Country	Project and company[3]	Project type[4]	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2011[5]	Australia	Niwest GME Resources Ltd.	new mine and heap-leaching operation	nickel	nickel-cobalt laterite ore	1,400	Nickel-cobalt sulfide.
2011	Do.	Ravensthorpe First Quantum Minerals Ltd.	reopen mine and modify existing PAL processing operation	do.	do.	1,400	Nickel-cobalt hydroxide.
2011	Canada	Lockerby Depth First Nickel Inc.	expansion of existing mine	do.	nickel-copper-cobalt sulfide ore	80 [6]	Nickel-copper-cobalt sulfide ore.
2011	Do.	Raglan Mine Xstrata Nickel	expansion of existing mine, stage 1	do.	nickel-copper-cobalt-platinum-group metals sulfide ore	NA [6]	Nickel concentrate.
2011	China	Cobalt plant, phase 1 Jiangwu Cobalt Co., Ltd. (Jiangxi Rare Earth & Rare Metals Tungsten Group Holding Co., Ltd., Ganzhou State-Owned Assets Management Co., Ltd., and Ganzhou Expressway Co., Ltd.)	new refinery	cobalt	NA	2,000	NA.
2011	Do.	Jiangsu Runjie New Material Nanjing Hanrui Cobalt Co., Ltd.	do.	do.	cobalt concentrate or cobalt carbonate	2,000	Cobalt metal powder, cobalt oxalate, cobalt carbonate, cobalt oxide.
2011	Congo (Kinshasa)	Kipoi, stage 1 Congo Minerals sprl (subsidiary of Tiger Resources Ltd.) and La Générale des Carrières et des Mines (Gécamines)	new mine and beneficiation plant	copper	copper-cobalt oxide ore	NA	Stockpiled cobalt ore or cobalt concentrate for sale.
2011	Do.	Luilu Metallurgical Plant, accelerated development plan, new phase 3 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	refurbishment and expansion of existing beneficiation plant and refinery	do.	copper-cobalt oxide and sulfide concentrates	8,000 [6]	Cobalt cathode.
2011	Do.	Luisha South DMS plant–stockpile African Metals Corp.	new beneficiation plant	do.	stockpiled copper-cobalt oxide ore	215	Copper-cobalt concentrate.
2011	Do.	Luita SX-EW line Boss Mining Sprl [Eurasian Natural Resources Corp. PLC and La Générale des Carrières et des Mines (Gécamines)]	addition to existing plant	cobalt	cobalt in solution	3,200 [7]	Cobalt cathode.

See footnotes at end of table.

TABLE 8—Continued

COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2015[1, 2]

Projected year of first production	Country	Project and company[3]	Project type[4]	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2011	Congo (Kinshasa)	Mutanda, phase I Mutanda Mining SPRL [Glencore International AG, Groupe Bazano, and La Générale des Carrières et des Mines (Gécamines)]	new refinery	copper	copper-cobalt oxide ore	11,000	Cobalt hydroxide.
2011	Do.	Mutanda, phase 2 Mutanda Mining SPRL [Glencore International AG, Groupe Bazano, and La Générale des Carrières et des Mines (Gécamines)]	expansion of existing operation	do.	do.	23,000 [6]	Do.
2011	Do.	NA Metal Mines SPRL (Nanjing Hanrui Cobalt Co., Ltd.)	new mines, beneficiation plant, and processing plant	do.	copper-cobalt ore	1,500	Cobalt carbonate.
2011	Papua New Guinea	Ramu Metallurgical Corporation of China Ltd., Jinchuan Group Ltd., Jilin Jien Nickel Industry Co., Ltd., Jiuquan Iron & Steel Group Co., Ltd., Highlands Pacific Ltd., and Mineral Resources Development Co.	new mine, beneficiation plant, and HPAL processing plant	nickel	nickel-cobalt laterite ore	3,300	Nickel-cobalt hydroxide.
2011	South Africa	Base Metals Refinery Anglo Platinum Ltd.	expansion of existing refinery	do.	nickel-cobalt-platinum-group metals converter matte	825 [e, 6]	Cobalt sulfate.
2011	Zambia	New Nchanga smelter Konkola Copper Mines Plc	expansion of production from existing smelter	copper	copper-cobalt concentrates	5,000 [6]	Alliage rouge.
2012	Australia	Cawse OJSC MMC Norilsk Nickel	reconfigure existing plant	nickel	nickel sulfide ore	NA	Nickel hydroxide.
2012[5]	Do.	Gladstone Nickel, stage 1 Gladstone Pacific Nickel Ltd.	new mine, beneficiation plant, HPAL processing plant, and refinery	do.	nickel-cobalt laterite ore	6,000	Cobalt metal.
2012	Do.	Mount Gunson MG 14 deposit Gunson Resources Ltd.	new mine and beneficiation plant	copper	copper-cobalt-silver sulfide ore	215	Copper-cobalt concentrate.
2012	Do.	Radio Hill Fox Resources Ltd.	new bacterial heap-leaching operation	nickel	nickel-copper sulfide ore and tailings	NA	Nickel-cobalt carbonate.
2012	Do.	Rocklands Group Copper CuDeco Ltd.	new mine and beneficiation plant	copper	copper-cobalt-gold oxide and sulfide ore	NA	Cobaltic-pyrite concentrate.
2012	Brazil	Sao Miguel Paulista refinery Votorantim Metais Niquel SA	expansion of existing refinery	nickel	nickel-cobalt matte	3,100 [6]	Cobalt cathode.
2012	Canada	Nunavik Nickel Jien Canada Mining Ltd. and Goldbrook Ventures Inc.	new mine and beneficiation plant	do.	nickel-copper-cobalt-platinum-group metals sulfide ore	425 [8]	Nickel concentrate.

See footnotes at end of table.

TABLE 8—Continued

COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2015[1, 2]

Projected year of first production	Country	Project and company[3]	Project type[4]	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2012	Congo (Kinshasa)	Luisha South DMS plant–hard rock African Metals Corp.	new mine and beneficiation plant	copper	copper-cobalt oxide and sulfide ores	NA	Copper-cobalt concentrate.
2012	Do.	Usoke refinery, EW plant for cobalt Chemaf SPRL	addition to existing refinery	do.	copper-cobalt ore	3,000 [7]	Cobalt cathode.
2012	Finland	Kevitsa First Quantum Minerals Ltd.	new mine and beneficiation plant	nickel	nickel-copper-cobalt-platinum-group metals-gold sulfide ore	400 [e, 8]	Nickel-cobalt-platinum-group metals concentrate.
2012	Do.	Outokumpu stage 1 (formerly Kylylahti) Altona Mining Ltd. (Universal Resources Ltd. and Vulcan Resources Ltd.)	new mine and refurbished beneficiation plant	copper	copper-zinc-cobalt-nickel-gold sulfide ore	940 [8]	Cobalt-nickel concentrate.[9]
2012	Do.	Talvivaara Talvivaara Mining Co. Ltd.	expansion of existing operation	nickel	nickel-zinc-copper-cobalt sulfide ore	1,800 [6]	Nickel-cobalt sulfide.
2012	Madagascar	Ambatovy Joint Venture Sherritt International Corp., Sumitomo Corp., Korea Resources Corp., SNC-Lavalin Group Inc.	new mine, HPAL processing plant, and refinery	do.	nickel-cobalt laterite ore	5,600	Cobalt metal powder and briquettes.
2012	South Africa	Middleburg smelter Jubilee Platinum plc	adapt existing smelter to include ConRoast process	platinum-group metals-nickel	platinum-group metals concentrates and sludge	NA	Nickel-copper-cobalt-iron-platinum-group metals alloy.
2012[5, 10]	Turkey	Caldag European Nickel PLC	mine and heap-leaching operation	nickel	nickel-cobalt laterite ore	1,000	Nickel-cobalt hydroxide.
2012	United States (Idaho)	Idaho Cobalt Formation Metals Inc.	new mine and refinery	cobalt	stratiform cobalt-copper-gold ore	1,625	Cobalt cathode.
2012	Zambia	Chambishi Copper Smelter China Nonferrous Metal Mining Group Co., Ltd. and Yunnan Copper Industry Group Co., Ltd.	expand existing smelter	copper	copper-cobalt concentrates	NA [11]	NA.
2012	Do.	Chambishi Metals Eurasian Natural Resources Corp. PLC	new SX-EW cobalt plant	do.	NA	3,000	Cobalt cathode.
2013	Australia	Barnes Hill Proto Resources & Investments Ltd. and Metals Finance Ltd.	new mine and ATML processing plant	nickel	nickel-cobalt laterite ore	400 [e]	Nickel-cobalt intermediate.
2013[5]	Do.	Wingellina Nickel Metals X Ltd.	new mine and HPAL processing plant	do.	do.	3,000 [8]	Nickel-cobalt hydroxide.
2013	Canada	NICO Fortune Minerals Ltd.	new mine, relocated and refurbished beneficiation plant, and refinery	gold	gold-cobalt-bismuth-copper ore	1,550 [8]	Cobalt cathode.

See footnotes at end of table.

TABLE 8—Continued

COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2015[1, 2]

Projected year of first production	Country	Project and company[3]	Project type[4]	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2013	Canada	Voisey's Bay Long-Harbour commercial nickel processing plant Vale S.A.	new refinery	nickel	nickel-copper-cobalt sulfide concentrate	2,500	Cobalt cathode.
2013	Congo (Kinshasa)	NA Boss Mining Sprl [(Eurasian Natural Resources Corp. PLC and La Générale des Carrières et des Mines (Gécamines)]	expansion of existing operations	copper	copper-cobalt oxide ore	12,000 [6]	NA.
2013	Do.	Usoke refinery Chemaf SPRL	expansion of existing refinery	do.	copper-cobalt ore	6,000 [6]	Cobalt cathode and cobalt hydroxide.
2013	Do.	WOL-SX-EW refinery, new phase 4 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	new beneficiation plant and SX-EW refinery	do.	copper-cobalt oxide and sulfide ore	12,000	Cobalt hydroxide.
2013	Japan	Niihama expansion Sumitomo Metal Mining Co., Ltd.	expansion of existing refinery	nickel	nickel-cobalt sulfide and nickel matte	4,500 [6]	Cobalt cathode.
2013	Mexico	El Boleo Baja Mining Corp., Korea Resources Corp., L.S. Nikko Copper Inc., Hyundai Hysco Co. Ltd., SK Networks Co. Ltd., and Iljin Copper Foil Co. Ltd.	new mine and refinery	copper	copper-cobalt-zinc-manganese oxide and sulfide ores	2,400	Do.
2013–14	Philippines	Mindoro Nickel Intex Resources ASA	new mine, beneficiation plant, ATML and HPAL processing plant, and refinery	nickel	nickel-cobalt laterite ore	3,300	Cobalt sulfate.
2013	Do.	Taganito Sumitomo Metal Mining Co., Ltd., Nickel Asia Corp., and Mitsui & Co., Ltd.	new HPAL processing plant	do.	do.	2,600	Nickel-cobalt sulfide.
2013	United States (Michigan)	Eagle Kennecott Eagle Minerals Co.	new mine, crusher, and rehabilitated beneficiation plant	nickel-copper	nickel-copper sulfide ore	400 [e]	Copper-nickel concentrate.
2013[e]	United States (Minnesota)	NorthMet PolyMet Mining Corp.	new mine, beneficiation plant, and refinery	copper	copper-nickel-platinum-group metals sulfide ore	360	Separate nickel and copper concentrates initially, followed by nickel-cobalt hydroxide.
2013	Zambia	Muliashi China Nonferrous Metal Mining Group Co., Ltd.	new mine, heap-leaching operation, and refinery	do.	copper-cobalt oxide ore	1,500	Cobalt hydroxide.

See footnotes at end of table.

TABLE 8—Continued

COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2015[1,2]

Projected year of first production	Country	Project and company[3]	Project type[4]	Principal metal	Ore/feed type	Annual production capacity (metric tons, cobalt content)	Cobalt product
2014	Cameroon	Nkamouna Geovic Mining Corp. and Société National d'Investissement du Cameroun	new mine and processing plant	cobalt	nickel-cobalt laterite ore	6,100 [8]	Cobalt-nickel sulfide.
2014[e]	Canada	Makwa Mustang Minerals Corp.	new mine and relocated beneficiation plant	nickel	nickel-copper-platinum-group metals sulfide ore	150 [e]	Nickel concentrate.
2014	Do.	Minago Victory Nickel Inc.	new mine and beneficiation plant	do.	nickel-copper-cobalt-platinum-group metals-precious metals sulfide ore	230 [e,8]	Do.
2014	Congo (Kinshasa)	Kipoi, stage 2 Congo Minerals sprl (subsidiary of Tiger Resources Ltd.) and La Générale des Carrières et des Mines (Gécamines)	addition of heap-leaching and SX-EW to existing operation	copper	copper-cobalt oxide ore	800	NA.
2014[e]	Do.	NA La Sino-Congolaise des Mines Sarl (Sicomines) joint venture[12]	new mine, beneficiation plant, and smelter	do.	copper-cobalt ore	19,000	Alliage blanc.
2014	Do.	Tenke Fungurume, phase 2 Freeport-McMoRan Copper & Gold Inc., Lundin Mining Corp., and La Générale des Carrières et des Mines (Gécamines)	expansion of existing operation	do.	copper-cobalt oxide, mixed oxide/sulfide, and sulfide ores	16,000 [6]	Cobalt hydroxide.
2014	Philippines	Acoje European Nickel PLC and DMCI Mining Corp.	new mine and heap-leaching operation	nickel	nickel-cobalt laterite ore	930 [8]	Nickel-cobalt hydroxide.
2014	Tanzania	Kabanga Barrick Gold Corp. and Xstrata Nickel	new mine and beneficiation plant	do.	nickel sulfide ore	NA	Nickel concentrate.
2014	Zambia	Ichimpe Zhonghui Mining Group Ltd.	new mine	copper	copper-cobalt ore	2,000	NA.
2015	Congo (Kinshasa)	WOL-SX-EW refinery, new phase 5 Katanga Mining Ltd. and La Générale des Carrières et des Mines (Gécamines)	expand new beneficiation plant and SX-EW refinery	do.	copper-cobalt oxide and sulfide ore	22,000 [6]	Cobalt hydroxide.

[e] Estimated. Do., do. Ditto. NA Not available.

[1] Estimated data are rounded to no more than three significant digits.

[2] Projects in feasibility or later stages of development in 2010. Actual startup dates may be postponed owing to economic or other factors. Additional projects might produce cobalt by 2015, but not enough information was available to include them.

[3] DMS dense media separation. EW electrowinning. SX-EW solvent extraction—electrowinning. WOL-SX-EW whole ore leach—solvent extraction—electrowinning.

[4] ATML Atmospheric leach. HPAL High pressure acid leach. PAL pressure acid leach. SX-EW solvent extraction—electrowinning.

[5] Startup date provided before project postponement was announced; no information is available on the length of delay.

TABLE 8—Continued

COBALT: SELECTED PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY 2015[1,2]

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[6] Total capacity following expansion.

[7] Addition will not increase total plant capacity.

[8] Average production.

[9] Cobalt-nickel concentrate will be stockpiled until a marketable product is developed.

[10] Placed on care-and-maintenance status until forestry permit is granted.

[11] Company plans to double copper capacity.

[12] The Sicomines joint venture comprises the following Chinese and Congolese companies: China Railway Group Ltd., Sinohydro Corp., Zhejiang Huayou Cobalt Co., Ltd., and La Générale des Carrières et des Mines (Gécamines).

TABLE 9
COBALT: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, cobalt content)

Country[3]	2006	2007	2008	2009	2010[e]
Australia[e, 4]	5,130	4,730	4,780	4,340 [r]	3,850 [5]
Botswana[6]	303	242	337	270 [r]	325
Brazil[e]	1,100	1,311 [5]	1,215 [5]	1,200	1,600
Canada[7]	7,115	8,692	8,953	3,919 [r]	4,568 [p, 5]
China[e]	1,840	6,100	6,630	6,000	6,500
Congo (Kinshasa)[e, 8]	27,100	25,400	32,300	35,500	47,400
Cuba[9]	5,602	4,540	3,175	3,500 [e]	3,600
Finland[e]	100	115	105 [5]	27	140
Indonesia[10]	1,600	1,600	1,300	1,200	1,600
Madagascar[e]	--	--	--	--	700
Morocco[e, 11]	2,600 [r]	1,800 [r]	1,700	2,200 [r]	2,200
New Caledonia[12]	1,629	1,620	869	719 [r]	1,000
Philippines[e]	900	1,000	1,200	1,500	2,200
Russia[e, 11]	6,300	6,300	6,200	6,100	6,200
South Africa[e]	600	600	590	610	1,800
Zambia[e, 13]	8,000	7,500	7,000 [r]	4,900 [r]	5,700
Zimbabwe[e, 14]	110	100	85	74 [5]	79 [5]
Total	70,000 [r]	71,700 [r]	76,400 [r]	72,100 [r]	89,500

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 9, 2011. Figures represent recoverable cobalt content of ores, concentrates, or intermediate products from cobalt, copper, nickel, platinum, or zinc operations.

[3] In addition to the countries listed, Spain and Turkey are known to produce ores that contain cobalt, but information is inadequate to make reliable estimates of production. Poland produces copper ore containing 1,500 to 5,000 metric tons per year of cobalt, which is not currently recovered. Other copper-, nickel-, platinum-, or zinc-producing nations may also produce ores containing cobalt as a byproduct component, but recovery is small or nil.

[4] Cobalt content of lateritic nickel ore, nickel concentrate, and zinc concentrate originating from Australia. Quantities of cobalt contained in intermediate or refined metallurgical products produced from Australian and imported ores, in metric tons, were estimated to be as follows: 2006–07—5,500; 2008—5,100; 2009—5,500; and 2010—5,700.

[5] Reported figure.

[6] Reported cobalt content of pelletized nickel-copper matte.

[7] Assay content of cobalt in concentrates produced.

[8] Cobalt content of concentrates, tailings, and slags.

[9] Determined from reported nickel-cobalt content of sulfide and ammoniacal liquor production.

[10] Cobalt content of nickel matte plus estimated cobalt in lateritic ore processed in Australia.

[11] Cobalt content of concentrates.

[12] Cobalt content of limonitic nickel laterite ores mined. Quantities of cobalt contained in intermediate or refined metallurgical products (cobalt chloride and cobalt oxide hydroxide) produced from New Caledonian ores exported to Australia and France, in metric tons, were estimated to be as follows: 2006—1,200; 2007—1,400; 2008—1,200; 2009—1,500; and 2010—1,700.

[13] Cobalt content of concentrates and slags.

[14] Estimated cobalt content of intermediate products produced in Zimbabwe from nickel and platinum ores mined in Zimbabwe.

TABLE 10

COBALT: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, cobalt content)

Country	2006	2007	2008	2009	2010
Australia, metal powder and oxide hydroxide[e]	3,700	3,680	3,620	4,050	4,120
Belgium, metal powder, oxide, hydroxide[3]	2,840	2,825	3,020	2,150	2,600
Brazil, metal	902	1,148	994	1,012	1,369
Canada, metal, metal powder, oxide	5,198	5,620	5,637	4,918	4,650 p
China, metal, metal powder, oxide, salts[e, 4]	12,700	13,200	18,200	23,100	32,900
Congo (Kinshasa), metal[5]	550	606	1,049	2,950	4,182
Finland, metal powder and salts[6]	8,582	9,173	9,645	8,962	9,413
France, chloride	256	305	311	368	302
India, metal and salts	1,184	980	858	1,001	1,187
Japan, metal	920	1,084	1,071	1,332	1,935
Morocco, metal and oxide	1,405	1,591	1,711	1,600	1,545
Norway, metal	4,927	3,939	3,719	3,510	3,208
Russia, unspecified[e, 7]	5,000	3,800	2,500	2,350	2,460
South Africa, metal powder and sulfate	267	307	244	238	833
Uganda, metal	674	698	663	673	624
Zambia, metal	4,665	4,335	4,049 r	1,506 r	5,026
Total	53,800	53,300	57,300 r	59,700 r	76,400

[e] Estimated. [p] Preliminary. [r] Revised.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 24, 2011. Figures represent cobalt refined from ores, concentrates, or intermediate products and do not include production of downstream products from refined cobalt.

[3] Production reported by n.v. Umicore s.a.; includes production from China that is not otherwise included in this table.

[4] Production from domestic and imported ores and concentrates; excludes production by n.v. Umicore s.a. that is included under Belgium.

[5] Excludes production of cobalt in alloys, carbonate, hydroxide and other materials that would require further refining.

[6] Production for 2006–08 reported by the Geological Survey of Finland; production for 2009–10 reported by OM Group Inc.

[7] Production reportedly includes metal, oxide, and salts; other forms may also have been produced.

COPPER

By Daniel L. Edelstein

Domestic survey data and tables were prepared by Samir Hakim, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In the United States, mine production of recoverable copper declined for the second consecutive year, decreasing by about 70,000 metric tons (t) to 1.10 million metric tons (Mt), and was down by almost 200,000 t from production in 2008. Although production declined slightly in Arizona and New Mexico as a result of curtailments following the collapse of copper prices during the fourth quarter of 2008, most of the decline was attributed to Utah, where lower ore grades at the leading U.S. copper producer led to a sharp decrease in production.

Despite numerous announced expansions in global mine capacity that totaled about 400,000 metric tons per year (t/yr), lower capacity utilization, particularly in the United States, resulted in a global copper mine production increase of only about 100,000 t compared with that in 2009. In addition to lower copper prices, numerous factors, including labor and political unrest, lower ore grades, technical problems, and utility shortages, continued to plague the industry and sustain a downward trend in capacity utilization. According to data compiled by the International Copper Study Group (ICSG), global mine capacity utilization has fallen to about 80% in 2010 from about 87% in 2006 (International Copper Study Group, 2011a, p. 9).

The United States fell from being the third ranked to the fourth ranked mine producer of copper behind Chile, Peru, and China and accounted for about 7% of global production. Chile remained the leading world mined copper producer, and accounted for 34% of global production. Global smelter production, which had declined nominally in 2009, rose by about 4% in 2010, as did downstream refinery production, owing to increased availability of scrap and copper concentrates. The United States ranked sixth in world smelter production and remained fourth in refinery output behind China, Chile, and Japan.

According to data compiled by the ICSG (2011a, p. 19–20), global consumption of refined copper, which had risen nominally (70,000 t) in 2009, rose by 7% (1.3 Mt) in 2010. In 2009, consumption declines in Europe, North America, and most major consuming regions of Asia were more than offset by an astronomical growth of almost 2 Mt (37%) in China's apparent consumption. China's apparent consumption is based on reported production, trade, and Shanghai Futures Exchange (SHFE) stock data, and does not include unreported Government or industry stocks, which may fluctuate significantly on an annual basis and were thought to have accumulated during 2009. In 2010, consumption in Europe and North America partially recovered from the 2009 downturn, increasing by 9% and 10%, respectively, although remaining below prerecession levels. In Asia, consumption rose by about 6% to a record-high level despite a more modest increase of more than 4% in China's apparent consumption.

In a reversal of the previous 2 years market balance, global production of refined copper in 2010 was insufficient to meet demand, and reported yearend 2010 global inventories of refined copper declined by about 145,000 t from those at yearend 2009 but remained at about 130,000 t above yearend 2008 inventories. The decline in global inventories took place despite a decline in China's imports of refined copper, which declined to 2.92 Mt in 2010 from 3.19 Mt in 2009 (International Copper Study Group, 2011a, p. 21, 29).

Copper prices during the first 8 months of 2010 fluctuated significantly. The daily COMEX price began 2010 at $3.39 per pound, ranged between $2.76 per pound (June 7) and $3.61 per pound (April 14), and averaged $3.23 per pound during the 8-month period, close to the December 2009 average of $3.19 per pound. Prices began a sustained rise in September with the yearend COMEX price rising to $4.44 per pound, the highest level of the year, and averaging $4.23 per pound in December and $3.43 for the full year, up from the 2009 average of $2.35 per pound.

The principal mining States for copper, in descending order of production, were Arizona, Utah, Nevada, New Mexico, and Montana, accounting for more than 99% of domestic production; copper was also recovered at mines in Idaho and Missouri. Although copper was recovered at 29 mines in the United States during 2010, 18 mines accounted for more than 99% of production (table 2). The remaining mines were either small leach operations or byproduct producers of copper.

In 2010, copper recovered from refined or remelted scrap (about 83% from new scrap and 17% from old scrap) composed 32% of the total U.S. copper supply. The conversion of old scrap to alloys and refined copper continued a downward trend and declined by 5% to 131,000 t of recoverable copper. Copper was consumed as refined copper and as direct melt scrap at about 30 brass mills, 15 wire-rod mills, and 500 chemical plants, foundries, and miscellaneous operations.

Legislation and Government Programs

On November 22, the International Trade Administration (ITA), U.S. Department of Commerce, published its final determination that an industry within the United States was being threatened with material injury from the import and sales of copper pipe and tube from China and Mexico at less than their fair market value. The determination required importers to deposit with the U.S. Customs and Border Protection Service a cash amount equal to the listed estimated weighted-average margins that ranged between 11.25% ad valorem and 60.85% ad valorem for nine Chinese exporters, and 24.89% and 27.16% for various Mexican exporters. The orders applied to all seamless circular refined copper pipes and tubes greater than or equal to 6 inches [152.4 millimeters (mm)] in length and measuring less than 12.130 inches (308.102 mm) in outside diameter regardless of wall thickness, bore finish, manufacturing process, outer surface or end finish, coating or insulation, end fitting, or physical configuration (straight, coiled, bent, etc.) (U.S. Department of Commerce, 2010b).

In December, three of the sanctioned Mexican tube exporters and their United States affiliates, along with the Government of Mexico, filed a request for a panel review with the United States section of the North American Free Trade Agreement (NAFTA) Secretariat. Chapter 19 of NAFTA provides a mechanism to request an independent binational panel to review final antidumping and countervailing duty in cases involving imports from a NAFTA country. When such a request is filed, a panel is established to act in place of national courts to expedite review of the final determination to see if it conforms with the antidumping or countervailing duty law of the country that made the determination (U.S. Department of Commerce, 2010a).

Production

Domestic mine production of copper decreased by about 6%, or about 70,000 t, to its lowest level since 1985, owing to closures and cutbacks announced during the fourth quarter of 2008 in response to the onset of a global recession and the plummet in copper prices. Estimated mine capacity, however, rose by about 30,000 t/yr to 1.73 million metric tons per year (Mt/yr), and as a result, capacity utilization declined to 64% from about 69% in 2009 and was at its lowest level in more than 25 years. Smelter production, however, remained unchanged as much of the decrease came from lower electrowon production, and exports of copper in concentrate declined. Downstream, electrolytic refined production declined by about 9,000 t, as permanent closure of the White Pine, MI, refinery in August, which had processed anodes imported from Canada, was partially offset by lower exports of domestically produced anode and increased production at the remaining three electrolytic refiners. Electrowon copper from leach solutions accounted for 39% and 41%, respectively, of mine and refinery production. Fifteen solvent extraction-electrowinning (SX-EW) facilities operated during 2010.

Operating Property Reviews.—Consolidated full-year production for ASARCO LLC's (Phoenix, AZ) mines in Arizona in 2010 totaled 209,000 t, an increase of about 13% from that in 2009, primarily owing to higher ore grades at the Mission and Ray Mines and improved recoveries at the Ray Mine. The Hayden smelter in Arizona produced 159,000 t of anode. Asarco produced 217,000 t of electrolytic copper, 158,000 t at its electrolytic refinery in Amarillo, TX, and a combined 59,000 t from its electrowinning operations at the Ray and Silver Bell Mines (Grupo México, S.A.B. de C.V., 2011, p. 29, 128).

Copper production from BHP Billiton's (Melbourne, Australia, and London, United Kingdom) residual Arizona leach operations at Miami and Pinto Valley remained unchanged at 6,000 t. Production of copper concentrate at Pinto Valley remained suspended (BHP Billiton, 2011, p. 2).

In late 2008 and early 2009, in response to the decline in copper and molybdenum prices, Freeport-McMoRan Copper & Gold Inc. (FCX) announced revised production plans that included cessation of mining at its Chino Mine in New Mexico; suspension of restart of mining at its residual leach operation in Miami, AZ; and about a 50% reduction in the operating rates at its Morenci and Safford Mines in Arizona and its Tyrone Mine in New Mexico. As a result, mine production at FCX's U.S. operations declined for the second consecutive year, falling by about 6% to 514,000 t from 554,000 t in 2009 and 691,000 t in 2008. Total unit costs, discounted for byproduct credit and including depreciation and other noncash costs, rose to $1.60 per pound of copper in 2010 from $1.44 per pound in 2009, despite an increase in byproduct credits to $0.35 per pound of copper from $0.23 in 2009 (Freeport-McMoRan Copper & Gold Inc., 2011a. p. 6–9, 23, 84).

In the first quarter of 2010, however, FCX restarted the Morenci mill to process available sulfide material and initiated a staged ramp up of the mining rate to 635,000 t/d from 450,000 t/d, with the goal of increasing its annual production rate by 57,000 t by the beginning of 2011. Mill throughput during the fourth quarter averaged 42,200 t/d of ore, up from 30,000 t/d at restart, and was expected to reach 50,000 t/d during 2011. Combined production (concentrate and electrowon) rose nominally in 2010 to 228,000 t. Although 2010 production at the Chino Mine of 15,400 t and the Miami Mine of 8,200 t came from residual leach during 2010, by the first quarter of 2010, FCX had initiated restart of mining at both operations. At Chino, FCX was investing $150 million in the mine and mill with targeted incremental production of 45,000 t in 2012 and 90,000 t in 2013, and at Miami, FCX expected to expend $40 million to increase production to 45,000 t/yr of copper cathode by late 2011 (Freeport-McMoRan Copper & Gold Inc., 2010, p. 4–5; 2011b, p. 3–4).

At FCX's Bagdad Mine in Arizona, copper production (concentrate and electrowon) declined to 92,000 t in 2010 from 102,000 t in 2009; at its Sierrita Mine in Arizona, production (concentrate and limited electrowon) decreased to 67,000 t from 77,000 t in 2009; and at its Tyrone Mine, production declined to 37,000 t from 39,000 t in 2009. At the Safford Mine, electrowon production decreased to 65,000 t from 83,000 t in 2009, and at yearend, construction of a $150 million sulfur burner to reduce the cost of sulfuric acid was underway and was expected to be completed in the second quarter of 2011 (Freeport-McMoRan Copper & Gold Inc., 2011a, p. 23, 82–83).

In 2010, despite a production decline to 250,000 t from 303,500 t in 2009, the Bingham Canyon Mine in Utah retained the position it regained in 2009 as the leading U.S. copper mine producer. Although the Copperton concentrator recorded record ore throughput, average copper head grades declined to 0.53% from 0.64% in 2009. Average molybdenum grades, however, increased to 0.045% from 0.038% in 2009, and molybdenum production increased to 12,900 t from 11,300 t. Production of refined copper decreased by about 2% to 269,000 t from 274,000 t in 2009. During 2010, mine operator Kennecott Utah Copper Corp. (Magna, UT) began the process of updating environmental permits to extend the mine life to 2028 through a possible combination of open pit and underground mining, and began constructing a $340 million molybdenum autoclave process (Rio Tinto plc, 2011, p. 3, 12, 22).

The Lisbon Valley Mine in Utah, formerly operated by bankrupt Constellation Copper Corp. (Denver, CO), was recapitalized, exited bankruptcy operating as Lisbon Valley Mining Co. LLC, and resumed mining and placement of new ore on leach pads. Production was expected to rise to about

8,200 t/yr of electrowon copper. Mining had ceased during the first quarter of 2008, and production had been from residual leach (Lisbon Valley Mining Co. LLC, 2010).

In 2010, following the completion of a phase I, 23,000-t/d mill during 2009, the Mineral Park Mine (Arizona) produced 14,600 t of copper (1,430 t from electrowinning) and 1,970 t of molybdenum. In February, Mercator Minerals Ltd. (Kingman, AZ, and Vancouver) began startup of its of phase 1.5 expansion to increase mill capacity to 27,000 t/d. Mill throughput during 2010 averaged 23,900 t/d. Mercator was proceeding with its phase 2 expansion that was expected to boost mill capacity to 45,000 t/yr during 2012 and in 2010, purchased a gas turbine to generate the additional power the expanded mill would require. Yearend mill reserves totaled 418 Mt, grading an average of 0.377% copper and containing 529,000 t of copper, and leach reserves totaled 67 Mt grading 0.07% copper and containing 47,000 t of copper (Mercator Minerals Ltd., p. 8–9, 26).

In July, Nord Resources Corp. (Dragoon, AZ) suspended mining and crushing of new ore at its Johnson Camp Mine in Arizona in order to maximize cash flow, conserve capital, and undertake additional geological and engineering studies prior to installation of a new leach pad. Leaching of residual copper from stockpiles continued. In January 2008, it had produced its first cathode since August 2003 from the leaching of stockpiles and in February 2009, it had resumed mining. Sales of copper cathode rose to 4,120 t in 2010 from 3,670 t in 2009, but following suspension of mining, sales in the fourth quarter fell to 697 t from 1,280 t in the fourth quarter of 2009 (Nord Resources Corp., 2011, p. 2–3).

On May 15, Quadra Mining Ltd. (Vancouver) merged with FNX Mining Co. Inc. (Toronto, Ontario, Canada) to become Quadra FNX Mining Co. with headquarters retained in Vancouver. FNX primarily held properties in the Sudbury mining district in Canada, including the McCreedy West and Levack Mines. Production at Quadra's Robinson Mine in Nevada decreased to 49,400 t from 55,600 t in 2009 owing to lower mill throughput from harder ore mined at the bottom of the Veteran pit. During the fourth quarter of the year, a shift in production from the Veteran and Ruth pits to just the Ruth pit was completed. At its Carlota Mine in Nevada, which produced its first cathode in December 2008, production of electrowon copper rose to 14,500 t from 12,700 t in 2009 but was lower than anticipated owing to heavy rains in both January and December (Quadra FNX Mining Ltd., 2011a, p. 1–8; b).

Developing Property Reviews.—Augusta Resource Corp. (Vancouver, British Columbia, Canada) continued development and permitting of the Rosemont Mine, about 50 kilometers southeast of Tucson, AZ. During 2010, it entered into several financial arrangements for mine development including a $176 million "earn-in agreement" with a South Korean consortium comprising the state-owned Korea Resources Corp. (Seoul, Korea) and LG International Corp. (Seoul) to acquire a 20% share in Rosemont. In November, Augusta delivered a full draft environmental impact statement (EIS) to the U.S. Forest Service, and in April 2011, the U.S. Forest Service announced its intent to issue a final decision in January 2012. Augusta anticipated building a 68,000-metric-ton-per-day (t/d) mill for sulfide ore and a heap-leach SX-EW facility with combined annual production of 100,000 t/yr of copper (Augusta Resource Corp., 2010a, b; 2011).

In February, Curis Resources Ltd. (Vancouver) acquired the assets, including permits, of the Florence Copper Project in Arizona from Merrill Ranch Investments LLC (Scottsdale, AZ, and Atlanta, GA). Prior to deferring development in 2000 and then divesting itself of the property, BHP Copper Co. had completed a prefeasibility study and obtained major environmental permits for an in situ leach copper operation. In October 2010, Curis announced a positive preliminary feasibility study, based on a base case of producing 35,000 t/yr of electrowon copper during a 19-year mine life, and was proceeding with amending and updating its operating permits with a goal of initiating copper production in 2012 (Curis Resources Ltd., 2010).

Formation Metals Inc. (Vancouver) was proceeding with its development of the underground Idaho Cobalt Project that was projected to produce about 2,000 t/yr of copper as a byproduct of cobalt production. In January, Formation announced that it had engaged JDS Energy and Mining Inc. to manage engineering and construction of the project, and in April, it announced that it had completed clearing of the mine site in preparation for constructing mine buildings and tailings disposal sites. As of April 2011, the company was pilot testing the hydrometalurgical complex, engaged in various engineering studies to update and complete the final complex design and equipment procurement, and was anticipating startup of construction during the second quarter of 2011 (Formation Metals Inc., 2010; 2011).

In 2010, Mines Management, Inc. (Spokane, WA) completed a preliminary economic assessment of its Montanore silver-copper project in northwestern Montana. The assessment was based on an average ore grade of 0.72% copper and 64 grams per metric ton (g/t) silver and production of 23,200 t/yr copper and 200 t/yr silver. The company was working to update lapsed environmental permits received prior to abandonment of the project in 2002 by its previous owner, Noranda Minerals Corp. During 2010, Mines Management responded to comments on its draft EIS released in 2009. The project hosts one of the world's largest known silver-copper deposits, with estimated resources containing more than 7,000 t of silver and nearly 780,000 t of copper (Mines Management, Inc., 2011, p. 5–8).

The Pebble Limited Partnership (Anchorage, AK), an equal partnership between Anglo American plc (London) and Northern Dynasty Minerals Ltd. (Vancouver), allocated more than $73 million for advancement of the Pebble project in southwest Alaska during 2010, increasing the amount invested in the project to about $500 million. An updated mineral resource assessment released in February increased estimates of contained copper, gold, and molybdenum by 12%, 14%, and 16%, respectively, from the December 2008 estimates. At a copper equivalent cutoff grade of 0.3% copper, the updated measured and indicated resources totaled 5.94 billion metric tons (Gt) grading 0.42% copper (0.78% copper equivalent) and containing 25 Mt of copper; the updated inferred mineral resource totaled 4.84 Gt grading 0.24% copper (0.53% copper equivalent) and containing 11.6 Mt of copper. An updated preliminary assessment, released in February 2011, found that the Pebble prospect could support a 200,000 t/d of ore open pit mine for a minimum of 25 years with a potential to extend to 78 years or beyond, or alternatively, the potential for an underground block-cave mine processing 136,000 t/d for mining beyond the initial 25-year period. Using a 45-year base case, the study concluded that the Pebble project could produce 14 Mt of copper while mining only 32% of the total Pebble resource; produce, at prevailing metal prices, an annual internal pretax rate of return of 23.2% and a 3.2-year payback; require an initial capital investment of $4.67 billion, exclusive of costs associated with outsourced power and port and road development; and would take 4 years to construct (Northern Dynasty Minerals Ltd., 2010; 2011, p. 1–3).

PolyMet Mining Corp. (Vancouver) was proceeding with the permitting of the NorthMet copper-nickel-precious metals project (mine and processing plant) in northeastern Minnesota, a process that began in 2002. In June, PolyMet announced that the State and Federal Government agencies responsible for the EIS would be preparing a supplemental draft EIS. In early 2011, Polymet announced its intent to simplify the phase 2 metallurgical process by eliminating a second autoclave and SX-EW circuit, instead opting to sell copper concentrates along with nickel-cobalt and precious metal products, reducing its environmental impact and reducing capital costs, based on 2008 estimates, by $127 million (Polymet Mining Corp., 2010; 2011).

Redstone Resources Corp. (Lakewood, CO) continued predevelopment work at the past-producing Zonia Mine (Arizona). Redstone was proceeding with five development programs aimed at generating a final feasibility study. A preliminary economic analysis, released in April 2011 (an update of the previous study released in December 2009) reported measured and indicated in-pit resources for a theoretical 27,000 t/d open pit leach operation of 100 Mt of ore grading an average of 0.28% copper (Redstone Resources Corp., 2011, p. 9).

Rio Tinto plc (London, United Kingdom) was proceeding with the development of two underground mines. Preproduction work continued on the Resolution copper sulfide mine operated by Resolution Copper Mining, LLC (55% Rio Tinto and 45% BHP Billiton) located more than 2,100 meters below the surface and beneath BHP Billiton's shuttered Magma Mine in Arizona, with the goal of beginning production by 2020. Resolution was seeking a land exchange required to access about 3,100 hectares of federally controlled property. Legislation introduced during 2009 in both houses of the U.S. Congress to facilitate the exchange was pending at yearend 2010. Rio Tinto also planned to invest $469 million in the Kennecott Eagle nickel and copper mine in the Upper Peninsula of Michigan, with first production expected in 2013 and production capacity of 17,300 t/yr and 13,200 t/yr of nickel and copper in concentrate, respectively. In support of these mine developments, as well as the Oyu Tolgoi Mine in Mongolia, Rio Tinto announced an expansion of its "Mine of the Future" program with a $10 million investment to develop new equipment and systems for deep underground mines and to create the Rio Tinto Centre for Underground Mine Construction in Sudbury, Ontario, Canada. The underground mining center would become the Rio Tinto's fifth global long-term research center (Resolution Copper Mining, LLC, 2009, p. 6–7; Rio Tinto plc, 2010a, b).

Consumption

Following an 18% decline in consumption in 2009 to the lowest level since the recession of 1975, U.S. reported consumption of refined copper increased by about 7% in 2010. Consumption by wire-rod producers, which accounted for 70% of reported consumption, increased by about 9%, and consumption by other consumers increased only nominally. Consumption by wire-rod producers was buoyed by a shift in wire-rod trade, the United States becoming a net exporter of 39,000 t of wire rod in 2010 from having had an essentially balanced net trade in 2009. According to data compiled by the American Bureau of Metal Statistics, Inc. (ABMS) (2011b), U.S. apparent consumption of wire rod in 2010 reversed a 4-year downward trend, increasing by about 6% from that in 2009.

According to ABMS, shipments of copper and copper alloy mill products by domestic producers rose by 13% in 2010 to 982,000 t, reversing a 5-year downward trend. From 2004 to 2010, however, apparent consumption (domestic shipments plus net imports), declined by 37%. In 2010, apparent consumption rose in all market segments, with the exception of copper tube (30% market share in 2010), where apparent consumption declined for the fifth consecutive year, decreasing by 4% in 2010, owing to the continued weak housing market and the continued substitution by plastic tube in residential markets. Apparent consumption of copper and copper alloy plate, sheet, and strip, with a combined 35% market share, rose by 22% in 2010; copper and copper alloy rod and bar, with a combined market share of 33%, rose by 27%; and copper alloy tube, with a market share of less than 2%, rose by 29% (American Bureau of Metal Statistics, Inc., 2011a).

According to preliminary data from the Copper Development Association Inc. (2011, p. 18–20), the total supply of copper and copper alloy products to the U.S. market by fabricators (brass mills, foundries, powder producers, and wire mills), which included net imports, rose by about 10% in 2010 from the revised shipments for 2009, reversing a 5-year downward trend. Wire-mill products accounted for about 53% of total shipments to the domestic market; brass mill products, 43%; and foundry and powder products, 4%. Shipments to the building construction sector, which remained the leading end-use market, were essentially unchanged and accounted for about 45% of shipments. Shipments to the electric and electronic products (23% market share), transportation equipment (13% market share), consumer and general products (12% market share), and industrial machinery and equipment (8% market share) sectors rose by 23%, 20%, 20%, and 7%, respectively.

Prices and Stocks

Although copper prices on average trended upward throughout 2010, the COMEX spot price, which began the year at $3.33 per pound of copper and averaged $3.43 per pound for the full year, fluctuated significantly through several cycles. Prices during the first 6 months of 2010 reached lows of $2.85 per pound and $2.76 per pound on February 5 and June 6, respectively, and peak values of $3.48 per pound and $3.63 per pound on January 6 and April 15, respectively. Although still fluctuating, prices generally trended upward during the last 6 months of the year; the COMEX price rising from $2.94 per pound at the end of June to its year-high value of $4.44 per pound on December 31.

The price cycles in the first half of the year correlated with China's import levels. After high yearend imports in December 2009 of 244,000 t, China's copper purchases declined in January to 197,000 t before climbing to 337,000 t in April, approaching the record-high import level of 379,000 t set in June 2009, before retreating back to 212,000 t in June 2010. Global exchange inventories (COMEX, London Metal Exchange Ltd., and SHFE) trended upward during the first 4 months of the year from 687,000 t at yearend 2009 to 778,000 t at the end of April, countering some of the influence of Chinese buying and contributing to the price volatility. Exchange stocks fell from May through September to about 540,000 t, where they remained through November, rising slightly at yearend to 568,000 t. Lower stock levels, continued strong imports by China (1.58 Mt in the last 6 months of 2010 compared with 1.34 Mt in the first 6 months of the year), and investment interest helped to sustain the price rise during the last 6 months of 2010. Full-year 2010 Chinese imports totaled 2.92 Mt, down from the record-high 3.19 Mt in 2009.

According to ICSG data, global demand for refined copper in 2010 exceeded production by about 350,000 t, reversing a 2-year trend during which production exceeded demand by a combined 375,000 t and reported yearend global inventories of refined copper rose by about 400,000 t. Global commodity exchange and industry stocks totaled 1.19 Mt at yearend 2010 and, at the average annual monthly rate of consumption, represented about 3.2 weeks of global supply (International Copper Study Group, 2011a, p. 9).

Copper scrap prices generally followed the trend in refined copper prices. With higher refined prices, however, the discount of most grades of copper scrap to refined copper increased. According to American Metal Market price data, the discount for refiners' No. 2 scrap from the COMEX spot price averaged 38.8 cents per pound for the year, above the average discount of 29.6 cents per pound in 2009, and ranged between 29.4 cents per pound in June and 65.9 cents per pound in December, when refined copper prices rose sharply. Higher refined copper prices and reduced export demand converged to raise the discount at yearend. Although following the same trend, the discount for No. 1 brass mill scrap remained much smaller, averaging 10.4 cents per pound for the year, and ranging between 6.6 cents per pound in May to 18.5 cents per pound in December.

Foreign Trade

Net refined copper imports in 2010 declined for the fourth consecutive year, falling by about 10% to 527,000 t. In light of lower imports and increased domestic demand, domestic inventories of copper, which had risen by about 235,000 t in 2009, declined by about 50,000 t in 2010. Chile, Canada, and Peru were the leading sources of refined copper imports in 2010, accounting for 51%, 28%, and 16%, respectively, of refined imports. From 2007 through 2010, Chile was the leading source of unwrought copper products (42%), followed by Canada (33%), and Peru (13%). Refined copper accounted for 83% of unwrought copper imports during the same period. Exports of copper contained in concentrates declined for the second consecutive year to 137,000 t, down from 301,000 t in 2008 and 151,000 t in 2009, owing to reduced mine production from nonintegrated producers and increased smelter operating rates at integrated producers, and after maintenance shutdowns reduced smelter output in 2008.

According to the U.S. Census Bureau data compiled by the Copper and Brass Fabricators Council Inc. (2011, p. 1–9), in 2010, U.S. imports of copper and copper-alloy semifabricated products (excluding wire-rod mill products) were 226,000 t (an increase of 17% from those in 2009), exports were 104,000 t (an increase of 6%), and the resulting net imports rose by 28% to 122,000 t. Canada and Mexico collectively accounted for 64% of semifabricated copper exports and 24% of imports. China, which had been the leading source of imports with a 26% share in 2009, accounted for only 13% of imports in 2010. In anticipation of the ITA antidumping orders finalized in November, imports of copper tube from China and Mexico declined by 55% (23,000 t) and 34% (8,000 t), respectively, from those in 2009.

Exports of copper and copper alloy scrap rose by 23% to a record-high 1.03 Mt. China (including Hong Kong) was the destination for 79% of domestic scrap exports and, based on global import data (official country trade data compiled by the ICSG), was the recipient of 62% of reported global scrap trade of 7.2 Mt. Germany and Belgium, the leading secondary copper smelting countries in Europe, were significant recipients of U.S. scrap, combined accounting for 4% of U.S. scrap exports and 12% of global imports in 2010, up from 3% and 11%, respectively, in 2009 (International Copper Study Group, 2011a, p. 41–43).

World Review

Following 2 years of limited growth, world production of refined copper rose by about 750,000 t (about 4%) led by an 11% increase in secondary refined production. Production of refined copper from primary materials rose by about 3%. After remaining stagnant for 2 years, world copper use, according to revised ICSG data, rose by about 7% to a record-high 19.4 Mt. Consequently, the ICSG global market balance indicated a production deficit of about 350,000 t, reversing a 2-year cumulative surplus of 350,000 t. Stocks held on the more visible commodity exchanges fell by about 120,000 t to 568,000 t, yet remained well above yearend 2008 stocks of 390,000 t. ICSG estimates of total reported inventories (exchanges, governments, and industry) fell by 160,000 t to 1.19 Mt. With the exception of exchange inventories, inventory levels in China were not reported and were discounted in these analyses. Consumption data for China are based on apparent consumption of refined copper (production, net trade, and SHFE stock changes) and did not account for changes in industry and government stock levels (International Copper Study Group, 2011a, p. 9–20).

World mine production of copper rose nominally (75,000 t) in 2010 to 16.0 Mt. World copper mine production had remained relatively flat from 2005 to 2010, increasing by only about 7% during the period. This low level of growth took place despite an estimated 19% capacity growth from 2005 to 2010, according to data compiled by the ICSG. Consequently, based on ICSG production and capacity data, capacity utilization at global copper mines trended consistently downward from 88.9% in 2005 to 80% in 2010. Numerous factors contributed to the downward trend, including competition for labor, power, and equipment during the prerecession global boom in mineral commodity production; labor unrest; preferential mining of coproducts; political uncertainty; and technical problems associated with aging and expanding operations. The sharp fall in prices during the fourth quarter of 2008 that had led to industry curtailments and delays or deferrals of anticipated projects continued to limit production in 2010 (International Copper Study Group, 2011b, p. 13).

Global smelter capacity and production increased by about 150,000 t/yr, and 700,000 t, respectively, in 2010 while production of copper in concentrates remained relatively unchanged at 12.7 Mt. Some of the concentrate shortfall was met by a 300,000-t increase in copper recovered from scrap. Consequently, concentrate supplies continued to remain tight through most of 2010 (International Copper Study Group, 2011b, p. 14).

According to CRU International Ltd. (2010, p. 73–77; 2011, p. 69–75) consumption of copper in concentrates exceeded supply by about 180,000 t and fell far short of global demand as smelter capacity utilization fell to 69.5% from 72.2% in 2008. CRU estimated that the cumulative 4-year deficit was about 460,000 t of copper in concentrate. The combined spot treatment (smelting) and refining charge (TC/RC), which had fallen to about 3 cents per pound during the fourth quarter of 2009, remained low during the first half of 2010, reportedly falling into negative figures during the second quarter based on an extreme tightness in the concentrate market. Spot purchases by the dominant Chinese smelters (75% to 80% of the spot market according to CRU estimates) softened during the second half of 2010, however, and spot TC/RCs rose to about 20 cents per pound during the fourth quarter of the year. Spot TC/RCs have trended lower since 2005, when they averaged about 40 cents per pound of copper. Term contracts were much less volatile and averaged about 10 to 12 cents per pound during the year.

After stagnating in 2009, global consumption of refined copper rose by about 7% (1.3 Mt) to a record-high 19.4 Mt in 2010. While Asia, dominated by China, had been the only major copper consuming region to experience growth during the preceding 3 years, consumption in all major consuming regions increased during 2010. In Asia, demand increased by about 10%, despite only 4% growth in China. As noted, China's apparent consumption excludes estimates of unreported stock changes, which can distort year-on-year changes. It is likely that significant stocks accumulated during 2009 when apparent consumption in China increased by 37%, significantly exceeding the country's 4.4% growth in semifabricate production. Conversely, some accumulated stocks likely were released during 2010 when semifabricate production increased by about 15.5% and apparent consumption of refined copper by only 4%. China remained the leading consumer of refined copper, however, accounting for 38% of world demand in 2010. In Japan, the fourth ranked consumer of copper, consumption rose by 21% to 1.06 Mt, but remained below the 2008 prerecession level. In the European Union-15 countries, the second leading consuming region after Asia, consumption rose by 8.7%, yet also remained below the 2008 level. Consumption in the United States-dominated North American market, the third leading consuming region, rose by about 6% (International Copper Study Group, 2011a, p.10–23).

Relatively little global realignment of the copper industry took place during 2010, with the exception that Grupo México, S.A.B. de C.V. rose to be the sixth and tenth ranked copper mine and refinery producer, respectively, following Chapter 11 restructuring of Asarco and its return to Grupo México's control at yearend 2009. Corporación Nacional del Cobré de Chile (Codelco) retained its position as the leading global mine producer of copper. FCX, BHP Billiton, Xstrata plc (Zug, Switzerland) (exclusive of Glencore's approximate 30% share), and Rio Tinto retained their positions as the second through fifth leading producers, respectively. Combined, the top 5 copper-producing companies accounted for 37% of global mine production, and the top 10 producers accounted for 54%. Codelco retained its position as the leading producer of refined copper, followed by Arubis AG (Hamburg, Germany), FCX, Jiangxi Copper Corp. (Guixi City, Jiangxi Province, China), and Xstrata. The top 5 refiners accounted for 30% of global copper mine production, and the top 10 refiners accounted for 45% (CRU International Ltd., 2011, p. 254).

Outlook

Refined copper prices reached record-high average levels in 2011, with the COMEX price averaging $4.00 per pound of copper. Prices, which began 2011 above $4.00 per pound, rose to record-high spot prices in mid-February, with the COMEX price peaking at $4.62 per pound, and generally trending downward to an average of $3.39 per pound in December. High imports of refined copper by China in the fourth quarter of 2010 and the first 2 months of 2011 supported the price rise. Although trending downward throughout the rest of 2011, continued tight supplies, as indicated by combined exchange inventories which finished the year slightly below those at yearend 2009, helped to support relatively high prices. According to preliminary ICSG data, world apparent consumption of refined copper for the first 9 months of 2011 increased by only about 1% above that for the same period of 2010, with consumption in China, the United States, and the European Union remaining essentially unchanged from that in the same period of 2010. Despite an earthquake and tsunami in March, consumption in Japan was down by only about 4% for the same comparative periods. Russia, where reinstatement of an export tariff on refined copper encouraged the conversion of cathode to wire rod prior to export, was the only country to experience significant growth in demand. Despite increases in capacity, world mine production for the first 9 months of 2011 was essentially unchanged from that in the same period of 2010 primarily owing to worker strikes that disrupted production in Chile and Indonesia. World refined production in the first 9 months of 2011, however, rose by almost 3%, principally owing to an almost 300,000-t increase in secondary refined production (International Copper Study Group, 2011a, p. 9–16).

In the United States, mine production in 2011 was essentially unchanged from that in 2010 as restoration of production that was cutback at yearend 2008 was mostly offset by lower ore grades at a major producer. Electrolytic refinery production declined owing to the 2010 closure of a refinery that treated imported anode and to lower domestic smelter output, the latter resulting in increased concentrate exports. U.S. copper mine production was expected to rise by more than 100,000 t in 2012, primarily owing to continued restoration of production. Domestic consumption of refined copper was nearly unchanged in 2011 despite economic improvement, in large part owing to a shift from being a net exporter to a net importer of wire rod. As a result of high prices and strong demand in China and Europe, exports of copper scrap from the United States rose by about 20% to a record-high 1.24 Mt.

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TABLE 1
SALIENT COPPER STATISTICS[1]

(Metric tons, unless otherwise specified)

		2006	2007	2008	2009	2010
United States:						
Mine production:						
Ore concentrated	thousand metric tons	163,000	138,000	156,000	149,000	152,000
Average yield of concentrated ore	percent	0.40	0.46	0.50	0.46	0.43
Recoverable copper:						
Arizona		712,000	731,000	836,000	711,000	703,000
New Mexico		113,000	108,000	104,000	56,500	52,700
Other States		372,000	329,000	368,000	414,000	353,000
Total		1,200,000	1,170,000	1,310,000	1,180,000	1,110,000
Total value	millions	$8,310	$8,450	$9,200	$6,290	$8,520
Smelter production:						
Primary and secondary		501,000	617,000	574,000	597,000	601,000
Byproduct sulfuric acid, sulfur content	thousand metric tons	576	720	655	671	682 [e]
Refinery production:						
Primary materials:						
Electrolytic from domestic ores		531,000	702,000	603,000	588,000	606,000
Electrolytic from foreign materials		144,000	62,100	109,000	48,300	21,000
Electrowon		530,000	504,000	507,000	476,000	430,000
Total		1,210,000	1,270,000	1,220,000	1,110,000	1,060,000
Secondary materials (scrap), electrolytic and fire refined		44,800	46,000	53,800	46,400	37,700
Grand total		1,250,000	1,310,000	1,270,000	1,160,000	1,090,000
Secondary copper produced:						
Recovered from new scrap		819,000	767,000	697,000	639,000 [r]	641,000
Recovered from old scrap		151,000	158,000	156,000	138,000 [r]	131,000
Total		969,000	925,000	852,000	777,000 [r]	772,000
Copper sulfate production		19,500	22,600	22,000	22,400	23,400
Exports, refined		106,000	51,100	36,500	80,800	78,300
Imports, refined		1,070,000	829,000	724,000	664,000	605,000
Stocks, December 31:						
Blister and in-process material		18,800	26,300	24,100	15,500	21,100
Refined copper:						
Refineries		28,100	21,800	18,300	23,700	10,300
Wire-rod mills		21,500	20,600	31,700	25,300	19,700
Brass mills		34,500	10,400	8,340	7,610	6,400
Other industry		3,280	3,220	3,230	4,290	4,380
COMEX		30,900	13,500	31,300	90,000	58,600
London Metal Exchange (LME), U.S. warehouses		75,600	60,600	106,000	283,000	284,000
Total		194,000	130,000	199,000	434,000	384,000
Consumption:						
Refined copper, reported		2,110,000	2,140,000	2,020,000	1,650,000	1,760,000
Apparent consumption, primary refined and old scrap[2]		2,200,000	2,270,000	1,990,000	1,580,000	1,740,000
Price:						
Producer, weighted average	cents per pound	314.75	328.00	319.16	241.24	348.34
COMEX, first position	do.	308.94	322.17	313.35	235.42	342.51
LME, Grade A cash	do.	304.85	322.83	315.47	233.56	341.74
World, production:						
Mine	thousand metric tons	15,100	15,500	15,600 [r]	15,900	16,000
Smelter	do.	14,100	14,300	14,700	14,900 [r]	15,600
Refinery	do.	17,300	17,900	18,300	18,400	19,100

See footnotes at end of table.

TABLE 1—Continued
SALIENT COPPER STATISTICS[1]

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[e]Estimated. [r]Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits, except prices; may not add to totals shown.

[2] In 2006, 2007, 2008, 2009, and 2010, apparent consumption is calculated using general imports of 1,080,000 metric tons (t), 832,000 t, 721,000 t, 645,000 t, and 583,000 t, respectively.

TABLE 2
LEADING COPPER-PRODUCING MINES IN THE UNITED STATES IN 2010, IN ORDER OF OUTPUT[1]

Rank	Mine	County and State	Operator	Source of copper	Capacity (thousand metric tons)
1	Bingham Canyon	Salt Lake, UT	Kennecott Utah Copper Corp.[2]	Copper-molybdenum ore, concentrated and leached	300
2	Morenci	Greenlee, AZ	Freeport-McMoRan Copper & Gold Inc.	do.	400
3	Ray	Pinal, AZ	ASARCO LLC	Copper ore, concentrated and leached	140
4	Bagdad	Yavapai, AZ	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore, concentrated and leached	110
5	Mission Complex	Pima, AZ	ASARCO LLC	Copper-molybdenum ore, concentrated	80
6	Sierrita	do.	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore, concentrated and leached	80
7	Safford	Graham, AZ	do.	Copper ore, leached	110
8	Robinson	White Pine, NV	Quadra Mining Ltd.	Copper-molybdenum ore, concentrated	70
9	Tyrone	Grant, NM	Freeport-McMoRan Copper & Gold Inc.	Copper ore, leached	50
10	Continental Pit	Silver Bow, MT	Montana Resources	Copper-molybdenum ore, concentrated	40
11	Silver Bell	Pima, AZ	ASARCO LLC	Copper ore, leached	22
12	Chino	Grant, NM	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore, leached	135
13	Mineral Park	Mohave, AZ	Mercator Minerals Ltd.	Copper-molybdenum ore, concentrated and leached	17
14	Carlota	Gila, AZ	Quadra Mining Ltd.	Copper ore, leached	15
15	Phoenix	Lander, NV	Newmont Mining Corp.	Gold-copper ore, concentrated	15
16	Miami	Gila, AZ	Freeport-McMoRan Copper & Gold Inc.	Copper ore, leached	50
17	Lisbon Valley	San Juan, UT	Lisbon Valley Mining Co. LLC	do.	7
18	Johnson Complex	Cochise, AZ	Nord Resources Corp.	do.	5

do. Ditto.

[1] The mines on this list accounted for more than 99% of U.S. mine production in 2010.

[2] Wholly owned subsidiary of Rio Tinto plc.

TABLE 3
MINE PRODUCTION OF COPPER-BEARING ORES AND RECOVERABLE COPPER CONTENT OF ORES PRODUCED IN THE UNITED STATES, BY SOURCE AND TREATMENT PROCESS[1]

(Metric tons)

Source and treatment process	2009 Gross weight	2009 Recoverable copper	2010 Gross weight	2010 Recoverable copper
Mined copper ore:				
Concentrated	149,000,000	683,000	152,000,000	659,000
Leached	NA	476,000	NA	430,000
Total	NA	1,160,000	NA	1,090,000
Copper precipitates shipped, leached from tailings, dumps, and in-place material	NA	W	NA	W
Other copper-bearing ores[2]	4,480,000	21,900	4,780,000	19,700
Grand total	XX	1,180,000	XX	1,110,000

NA Not available. W Withheld to avoid disclosing company proprietary data; included with "Other copper-bearing ores." XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes gold ore, lead ore, silver ore, and zinc ore.

TABLE 4

CONSUMPTION OF COPPER AND BRASS MATERIALS IN THE UNITED STATES, BY ITEM[1]

(Metric tons)

Item	Brass mills	Wire-rod mills	Foundries, chemical plants, miscellaneous users	Smelters, refiners, ingot makers	Total
2009:					
Copper scrap	685,000 [r, 2]	W	67,100 [r]	159,000	911,000 [r]
Refined copper[3]	454,000	1,140,000	49,500	4,510	1,650,000
Hardeners and master alloys	9,990	--	3,090	--	13,100
Brass ingots	--	--	55,400 [r]	--	55,400 [r]
Slab zinc	44,800	--	(4)	(4)	107,000
2010:					
Copper scrap	694,000 [2]	W	66,100	150,000	911,000
Refined copper[3]	459,000	1,250,000	53,100	4,510	1,760,000
Hardeners and master alloys	10,100	--	4,370	--	14,400
Brass ingots	--	--	61,700	--	61,700
Slab zinc	44,800	--	(4)	(4)	106,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Brass mills." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes item indicated by symbol W.

[3] Detailed information on consumption of refined copper can be found in table 5.

[4] Withheld to avoid disclosing company proprietary data; included in "Total."

TABLE 5

CONSUMPTION OF REFINED COPPER SHAPES IN THE UNITED STATES, BY CLASS OF CONSUMER[1]

(Metric tons)

Class of consumer	Cathodes	Ingots and ingot bars	Cakes and slabs	Wirebar, billets, other	Total
2009:					
Wire-rod mills	1,140,000	--	--	4,620	1,140,000
Brass mills	313,000	24,200	43,600	72,800	454,000
Chemical plants	--	--	--	367	367
Ingot makers	W	W	W	4,510 [2]	4,510
Foundries	3,450	3,240	--	12,400	19,100
Miscellaneous[3]	W	W	W	30,100 [2]	30,100
Total	1,450,000	27,400	43,600	125,000	1,650,000
2010:					
Wire-rod mills	1,250,000	--	--	--	1,250,000
Brass mills	320,000	19,400	44,100	75,600	459,000
Chemical plants	--	--	--	385	385
Ingot makers	W	W	W	4,510 [2]	4,510
Foundries	3,470	3,150	--	11,500	18,200
Miscellaneous[3]	W	W	W	34,600 [2]	34,600
Total	1,570,000	22,500	44,100	127,000	1,760,000

W Withheld to avoid disclosing company proprietary data; included with "Wirebar, billets, other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes items indicated by symbol W.

[3] Includes consumers of copper powder and copper shot, iron and steel plants, and other manufacturers.

TABLE 6
COPPER RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY[1]

(Metric tons)

	2009	2010
Kind of scrap:		
New scrap:		
Copper-base	608,000	611,000
Aluminum-base	30,400 [r]	30,300
Nickel-base	18	18
Total	639,000 [r]	641,000
Old scrap:		
Copper-base	120,000	109,000
Aluminum-base	17,800 [r]	21,800
Nickel-base	267	266
Zinc-base	9	9
Total	138,000 [r]	131,000
Grand total	777,000 [r]	772,000
Form of recovery:		
As unalloyed copper	47,100	39,000
In brass and bronze	676,000 [r]	676,000
In alloy iron and steel	673	731
In aluminum alloys	48,200 [r]	51,900
In other alloys	8	9
In chemical compounds	5,030	5,030
Total	777,000 [r]	772,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 7
COPPER RECOVERED AS REFINED COPPER AND IN ALLOYS AND OTHER FORMS FROM COPPER-BASE SCRAP PROCESSED IN THE UNITED STATES, BY TYPE OF OPERATION[1]

(Metric tons)

	From new scrap		From old scrap		Total	
Type of operation	2009	2010	2009	2010	2009	2010
Ingot makers	11,500	11,700	62,400	59,800	73,900	71,500
Refineries[2]	20,800	19,100	25,600	18,600	46,400	37,700
Brass and wire-rod mills	545,000	548,000	16,500	17,200	561,000	565,000
Foundries and manufacturers	26,100 [r]	27,700	15,300 [r]	13,300	41,400 [r]	40,900
Chemical plants	5,030	5,030	--	--	5,030	5,030
Total	608,000	611,000	120,000	109,000	728,000	720,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes electrolytically refined based on source of material at smelter level.

TABLE 8
PRODUCTION OF SECONDARY COPPER AND COPPER-ALLOY PRODUCTS IN THE UNITED STATES, BY ITEM PRODUCED FROM SCRAP[1]

(Metric tons)

Item produced from scrap	2009	2010
Unalloyed copper products:		
Refined copper	46,400	37,700
Copper powder	587	1,230
Copper castings	82	82
Total	47,100	39,000
Alloyed copper products:		
Brass and bronze ingots:		
Tin bronzes	6,890	7,870
Leaded red brass and semired brass	52,400	46,100
High leaded tin bronze	7,330	8,450
Yellow brass	4,870	5,060
Manganese bronze	7,260	7,390
Aluminum bronze	5,860	5,920
Nickel silver	1,060	1,040
Silicon bronze and brass	4,710	4,620
Copper-base hardeners and master alloys	7,670	7,670
Miscellaneous	6,090	7,720
Total	104,000	102,000
Brass mill and wire-rod mill products	678,000	689,000
Brass and bronze castings	38,800 [r]	35,800
Copper in chemical products	5,030	5,030
Grand total	873,000	871,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 9
COMPOSITION OF SECONDARY COPPER-ALLOY PRODUCTION IN THE UNITED STATES[1]

(Metric tons)

	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze ingot production:[2]							
2009	86,700 [r]	3,240 [r]	4,910 [r]	9,130 [r]	116	11	104,000
2010	84,300	3,600	5,070	8,730	113	13	102,000
Secondary metal content of brass mill products:							
2009	565,000	1,180	2,270	109,000	860	16	678,000
2010	570,000	1,400	2,020	115,000	1,060	16	689,000
Secondary metal content of brass and bronze castings:							
2009	35,200 [r]	1,170	578 [r]	1,640 [r]	203 [r]	97	38,800 [r]
2010	32,400	1,100	574	1,460	130	101	35,800

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes approximately 96% from scrap and 4% from other than scrap in 2009 and 2010.

TABLE 10

CONSUMPTION AND YEAREND STOCKS OF COPPER-BASE SCRAP[1]

(Metric tons, gross weight)

	2009		2010	
Scrap type and processor	Consumption	Stocks	Consumption	Stocks
Unalloyed scrap:				
No.1 wire and heavy:				
Smelters, refiners, and ingot makers	45,000	968	17,300	849
Brass and wire-rod mills	332,000	(2)	319,000	(2)
Foundries and miscellaneous manufacturers	16,800	(2)	18,800	(2)
No. 2 mixed heavy and light:				
Smelters, refiners, and ingot makers	40,600	2,240	59,700	2,500
Brass and wire-rod mills	8,590	(2)	10,200	(2)
Foundries and miscellaneous manufacturers	6,450	(2)	7,260	(2)
Total unalloyed scrap:				
Smelters, refiners, and ingot makers	85,600	3,210	76,900	3,350
Brass and wire-rod mills	341,000	369 [r]	330,000	686
Foundries and miscellaneous manufacturers	23,300	1,670	26,000	1,920
Alloyed scrap:				
Red brass:[3]				
Smelters, refiners, and ingot makers	20,600	1,550	22,500	1,560
Brass mills	9,230	(2)	11,100	(2)
Foundries and miscellaneous manufacturers	5,950	(2)	2,790	(2)
Leaded yellow brass:				
Smelters, refiners, and ingot makers	9,970	640	9,930	820
Brass mills	116,000	(2)	103,000	(2)
Foundries and miscellaneous manufacturers	1,000	(2)	971	(2)
Yellow and low brass, all plants	127,000	577 [r]	146,000	491
Cartridge cases and brass, all plants	87,800	(2)	98,200	(2)
Auto radiators:				
Smelters, refiners, and ingot makers	20,200	774	18,100	862
Foundries and miscellaneous manufacturers	1,900	(2)	1,900	(2)
Bronzes:				
Smelters, refiners, and ingot makers	10,800	612	11,900	874
Brass mills and miscellaneous manufacturers	15,800	(2)	16,300	(2)
Nickel-copper alloys, all plants	9,060 [r]	178 [r]	9,730	152
Low grade and residues; smelters, refiners, miscellaneous manufacturers	23,300	605 [r]	23,000	468
Other alloy scrap:[4]				
Smelters, refiners, and ingot makers	1,110	191	1,290	412
Brass mills and miscellaneous manufacturers	5,270	(2)	5,340	(2)
Total alloyed scrap:				
Smelters, refiners, and ingot makers	73,700	5,010	73,700	5,510
Brass mills	347,000	545 [r]	368,000	547
Foundries and miscellaneous manufacturers	43,800 [r]	2,330 [r]	40,100	2,020
Total scrap:				
Smelters, refiners, and ingot makers	159,000	8,220	151,000	8,860
Brass and wire-rod mills	688,000	914 [r]	698,000	1,230
Foundries and miscellaneous manufacturers	67,100 [r]	4,000 [r]	66,100	3,930

See footnotes at end of table.

TABLE 10—Continued
CONSUMPTION AND YEAREND STOCKS OF COPPER-BASE SCRAP[1]

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[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Individual breakdown is not available; included in "Total unalloyed scrap," "Total alloyed scrap," and "Total scrap."

[3] Includes cocks and faucets, commercial bronze, composition turnings, gilding metal, railroad car boxes, and silicon bronze.

[4] Includes aluminum bronze, beryllium copper, and refinery brass.

TABLE 11
CONSUMPTION OF PURCHASED COPPER-BASE SCRAP[1,2]

(Metric tons, gross weight)

Type of operation	From new scrap		From old scrap		Total	
	2009	2010	2009	2010	2009	2010
Ingot makers	34,000 r	34,500	78,100 r	77,200	112,000	112,000
Smelters and refineries	24,300	20,100	22,900	18,800	47,200	38,900
Brass and wire-rod mills	671,000	681,000	16,900	17,500	688,000	698,000
Foundries and miscellaneous manufacturers	50,700 r	48,200	16,400 r	17,900	67,100 r	66,100
Total	780,000 r	783,000	134,000 r	131,000	915,000 r	915,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Consumption at brass and wire-rod mills assumed equal to receipts.

TABLE 12
FOUNDRIES AND MISCELLANEOUS MANUFACTURERS CONSUMPTION OF BRASS INGOT, REFINED COPPER, AND COPPER SCRAP IN THE UNITED STATES[1]

(Metric tons)

Ingot type or material consumed	2009	2010
Tin bronzes	8,340	9,160
Leaded red brass and semired brass	33,700	36,700
Yellow, leaded, low brass[2]	6,080	7,250
Manganese bronze	2,240	2,420
Nickel silver[3]	620	483
Aluminum bronze	3,020	3,440
Hardeners and master alloys[4]	3,090	4,370
Lead free alloys[5]	1,420	2,170
Total brass ingot	58,500	66,000
Refined copper	49,500	53,100
Copper scrap	67,100 r	66,100

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes brass and silicon bronze.

[3] Includes brass, copper nickel, and nickel bronze.

[4] Includes special alloys.

[5] Includes copper-bismuth and copper-bismuth-selenium alloys.

TABLE 13
AVERAGE PRICES FOR COPPER SCRAP, BY TYPE

(Cents per pound)

Year	Brass mills No. 1 scrap	Refiners No. 2 scrap	Dealers' buying (New York) No. 2 scrap	Dealers' buying (New York) Red brass turnings and borings
2009	226.83	205.85	159.16	112.93
2010	325.19	297.67	252.40	164.12

Source: American Metal Market.

TABLE 14

U.S. EXPORTS OF UNMANUFACTURED COPPER (COPPER CONTENT), BY COUNTRY[1]

	Ore and concentrate		Matte, ash, and precipitates		Blister and anodes		Refined		Unalloyed copper scrap		Total	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009	151,000	$743,000	40,900	$63,800	26,000	$98,600	80,800	$375,000	245,000	$856,000	543,000	$2,140,000
2010:												
Belgium	70	458	844	2,700	102	433	303	503	11,000	52,600	12,300	56,700
Canada	12,800	91,000	41,400	88,000	6,010	22,600	8,030	49,000	15,500	109,000	83,800	360,000
China	82,300	566,000	455	2,630	294	2,380	34,300	223,000	247,000	1,060,000	365,000	1,860,000
Germany	18	104	846	1,250	2,160	9,350	30	152	4,190	25,500	7,240	36,400
Hong Kong	--	--	--	--	1,740	13,500	4,690	34,800	10,300	53,500	16,700	102,000
India	--	--	--	--	458	3,470	66	295	965	5,960	1,490	9,720
Japan	9,610	66,300	100	395	1,920	17,400	39	69	7,180	48,600	18,800	133,000
Korea, Republic of	3,100	23,600	--	--	659	5,360	113	193	13,300	88,200	17,200	117,000
Mexico	24,700	140,000	--	--	670	4,020	16,100	119,000	4,090	25,400	45,500	289,000
Taiwan	1	5	--	--	454	3,450	800	5,390	2,940	17,000	4,200	25,800
Other	3,960	27,900	286	432	2,400	17,500	13,800	82,900	16,700	101,000	37,200	230,000
Total	137,000	916,000	44,000	95,400	16,900	99,400	78,300	515,000	334,000	1,590,000	609,000	3,220,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 15

U.S. EXPORTS OF COPPER SEMIMANUFACTURES, BY COUNTRY[1]

Country	Pipes and tubing		Plates, sheets, foil, bars		Bare wire, including wire rod[2]		Wire and cable, stranded		Copper sulfate	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009	21,200	$164,000	20,700	$138,000	126,000	$668,000	20,400	$163,000	5,880	$9,700
2010:										
Australia	20	176	28	251	390	3,080	73	585	14	27
Brazil	39	347	91	806	3	58	15	3,170	--	--
Canada	7,790	70,000	7,160	65,000	37,400	275,000	8,930	78,500	2,120	4,910
China	139	1,820	2,690	19,400	4,250	28,800	1,500	17,200	1,180	2,090
Denmark	1	15	1	18	1	13	4	233	--	--
France	2	27	32	723	20	393	36	1,110	--	--
Germany	3	72	194	3,250	241	6,000	100	2,830	478	896
Hong Kong	6	72	249	2,720	229	779	129	5,110	--	--
Italy	28	249	21	550	28	406	16	405	--	--
Japan	2	36	224	3,700	15	363	256	4,520	88	121
Korea, Republic of	59	1,020	363	3,370	386	3,360	129	5,910	92	83
Malaysia	5	35	665	5,380	117	3,810	16	382	124	162
Mexico	7,510	67,600	9,770	82,700	118,000	756,000	11,000	93,500	143	201
Netherlands	82	718	78	1,680	31	634	18	540	333	634
Saudi Arabia	665	5,510	13	130	11	82	242	2,480	42	33
Singapore	56	1,160	165	1,860	24	277	82	1,910	21	20
Sweden	(3)	4	(3)	20	34	922	1	77	--	--
Taiwan	11	167	1,580	10,600	114	750	31	995	1,010	1,380
Thailand	31	428	55	754	18	294	16	558	--	--
United Kingdom	172	1,660	30	900	106	1,270	92	1,320	16	26
Other	850	7,930	660	7,370	1,590	19,900	2,690	35,000	2,300	3,510
Total	17,500	159,000	24,100	211,000	163,000	1,100,000	25,400	256,000	7,970	14,100

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Total exports of wire rod in 2009 were 113,000 metric tons (t) valued at $572 million, and in 2010, wire rod exports were 144,000 t valued at $940 million.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 16

U.S. IMPORTS FOR CONSUMPTION OF UNMANUFACTURED COPPER (COPPER CONTENT), BY COUNTRY[1]

Country	Ore and concentrate		Matte, ash, and precipitates		Blister and anode		Refined		Unalloyed scrap		Total	
	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
2009	137	$271	759	$2,260	68,400	$389,000	664,000	$3,120,000	16,300	$52,000	749,000	$3,570,000
2010:												
Brazil	--	--	--	--	--	--	1,980	14,100	--	--	1,980	14,100
Canada	1,270	1,960	310	1,110	21,700	157,000	168,000	1,230,000	9,010	53,500	200,000	1,450,000
Chile	--	--	--	--	--	--	308,000	2,290,000	--	--	308,000	2,290,000
Costa Rica	--	--	--	--	--	--	--	--	867	3,520	867	3,520
Dominican Republic	--	--	--	--	--	--	--	--	628	1,180	628	1,180
Finland	--	--	--	--	348	2,470	1	11	--	--	348	2,480
Germany	--	--	--	--	(3)	4	3,180	24,100	28	64	3,210	24,200
Japan	--	--	3	15	15	1,400	4,990	43,100	14	53	5,030	44,600
Mexico	17	13	--	--	3,990	38,700	19,200	149,000	5,850	18,100	29,000	206,000
Peru	--	--	--	--	--	--	97,100	706,000	--	--	97,100	706,000
Other	110	264	527	1,930	163	1,590	2,400	16,400	4,990	13,900	8,190	34,100
Total	1,390	2,240	840	3,050	26,300	201,000	605,000	4,470,000	21,400	90,400	655,000	4,770,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, freight value at U.S. port.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 17

U.S. IMPORTS FOR CONSUMPTION OF COPPER SEMIMANUFACTURES, BY COUNTRY[1]

Country	Pipes and tubing		Plates, sheets, foil, bars		Bare wire, including wire rod[2]		Wire and cable, stranded		Copper sulfate	
	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)
2009	1,670	$12,700	42,500	$290,000	120,000	$594,000	10,900	$69,600	49,300	$88,200
2010:										
Brazil	--	--	1,240	10,500	8	88	(4)	4	--	--
Canada	13	117	2,150	18,300	99,800	749,000	539	4,520	4,540	9,290
Chile	65	504	4,630	35,400	35	205	--	--	3,050	6,430
China	30	181	2,300	18,900	304	3,210	317	2,130	4,720	6,890
Finland	245	3,300	4,380	41,400	609	6,020	--	--	3	25
France	5	211	1,600	13,400	90	5,750	39	821	--	--
Germany	260	3,000	21,600	200,000	1,010	11,100	111	2,240	130	186
Israel	--	--	3	23	326	3,520	(4)	5	--	--
Italy	14	210	740	6,070	1	103	7	110	1	7
Japan	16	257	1,050	15,600	225	5,000	2	34	27	485
Korea, Republic of	(4)	18	892	9,250	244	1,680	548	3,060	32	246
Luxembourg	--	--	1,250	16,400	--	--	--	--	--	--
Mexico	3,440	26,800	3,430	28,800	8,680	63,700	173	2,110	30,400	71,900
Peru	--	--	5,170	42,700	1,120	8,820	--	--	873	1,940
Russia	--	--	--	--	1	5	--	--	985	3,280
Sweden	(4)	4	4,990	45,400	9	98	--	--	--	--
Taiwan	1	24	230	2,310	150	1,050	70	951	2,690	5,780
Turkey	--	--	(4)	5	13	108	6,730	57,700	--	--
United Kingdom	1	18	545	4,410	36	297	1	69	20	48
Other	23	234	1,370	11,900	1,100	13,300	1,680	17,400	482	953
Total	4,120	34,900	57,600	521,000	114,000	873,000	10,200	91,200	48,000	107,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Total imports of wire rod in 2009 were 113,000 metric tons (t) valued at $545 million, and in 2010, wire rod imports were 105,000 t valued at $789 million.

[3] Cost, insurance, freight value at U.S. port.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 18
U.S. EXPORTS OF COPPER SCRAP, BY COUNTRY [1]

	Unalloyed copper scrap				Copper-alloy scrap			
	2009		2010		2009		2010	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium	2,160	$7,750	11,000	$52,600	14,900	$31,800	19,900	$66,600
Canada	6,320	34,800	15,500	109,000	32,300	91,500	29,900	110,000
China	190,000	617,000	247,000	1,060,000	416,000	693,000	512,000	1,300,000
Germany	1,510	6,510	4,190	25,500	6,600	31,900	9,570	54,500
Hong Kong	15,600	63,100	10,300	53,500	37,400	85,600	44,500	158,000
India	356	1,480	965	5,960	11,100	23,200	17,900	40,700
Japan	3,220	15,900	7,180	48,600	10,200	46,200	9,900	58,500
Korea, Republic of	8,400	36,500	13,300	88,200	21,500	48,800	17,600	63,400
Mexico	1,580	8,770	4,090	25,400	9,990	41,300	7,090	49,900
Taiwan	6,980	23,300	2,940	17,000	6,510	5,680	2,790	8,500
Other	8,420	40,900	16,700	101,000	31,200	52,300	28,800	57,100
Total	245,000	856,000	334,000	1,590,000	598,000	1,150,000	699,000	1,960,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 19
U.S. IMPORTS FOR CONSUMPTION OF COPPER SCRAP, BY COUNTRY [1]

	Unalloyed copper scrap		Copper-alloy scrap		
Country or territory	Quantity (metric tons)	Value[2] (thousands)	Gross weight (metric tons)	Copper content [3] (metric tons)	Value[2] (thousands)
2009	16,300	$52,000	55,500	40,000	$185,000
2010:					
Canada	9,010	53,500	32,500	23,400	156,000
Chile	--	--	80	58	318
Costa Rica	867	3,520	2,100	1,510	9,440
Dominican Republic	628	1,180	856	616	1,230
Guatemala	651	1,290	1,070	770	3,710
Honduras	20	143	701	504	3,520
Jamaica	237	535	361	260	620
Mexico	5,850	18,100	29,900	21,500	107,000
Nicaragua	1,270	2,640	1,330	958	2,010
Peru	--	--	438	315	3,200
Other	2,850	9,430	5,080	3,660	25,200
Total	21,400	90,400	74,500	53,600	313,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, freight value at U.S. port.

[3] Content is estimated by the U.S. Geological Survey to be 72% of gross weight.

Source: U.S. Census Bureau.

TABLE 20

COPPER: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Argentina	180,144	180,200	156,893	143,084	140,318
Armenia	18,000 [e]	17,600 [e]	18,800	22,600	25,100
Australia:[e]					
Concentrates	806,400 [3]	828,000	833,000	831,000	856,000
Leaching, electrowon	52,400 [3]	42,000	53,000	23,000	14,400
Total	858,800 [3]	870,000	886,000	854,000	870,000
Bolivia	218	606	731	882 [r]	2,063
Botswana[e]	24,000	24,000	29,000	27,700 [r]	31,000
Brazil:					
Concentrates	147,836	204,828	214,495	205,192	206,800
Leaching, electrowon	--	900	3,800	6,500	7,400
Total	147,836	205,728	218,295 [r]	211,692 [r]	214,200
Bulgaria	110,000	110,000 [r]	105,000 [r]	105,000 [r]	105,000
Burma, leaching, electrowon	19,500	13,900 [r]	-- [r]	3,500 [r]	12,000
Canada:					
Concentrates	603,295	594,749	605,399	493,700 [r]	522,000
Leaching, electrowon	--	1,500	1,600	800	3,000
Total	603,295	596,249	606,999	494,500 [r]	525,000
Chile:[4]					
Concentrates	3,669,000	3,724,900	3,356,600	3,276,900	3,330,400
Leaching, electrowon	1,691,800	1,832,100	1,971,000	2,117,500 [r]	2,088,500
Total	5,360,800	5,557,000	5,327,600	5,394,400 [r]	5,418,900
China:[e]					
Concentrates	873,000	928,000	1,070,000 [r]	1,040,000 [r]	1,160,000
Leaching, electrowon	16,000	18,000	20,000	25,000	35,000
Total	889,000	946,000	1,090,000 [r]	1,070,000 [r]	1,200,000
Colombia	725	1,050	1,310	1,420	1,000
Congo (Kinshasa):[5]					
Concentrates[e]	91,000 [r]	116,000 [r]	189,000 [r]	155,000 [r]	118,000
Leaching, electrowon	53,285	32,099 [r]	44,742 [r]	154,751 [r]	262,000 [e]
Total	144,285 [r]	148,099 [r]	233,742 [r]	309,751 [r]	380,000 [e]
Cyprus, leaching, electrowon[e]	--	300	300	300	300
Dominican Republic	--	--	2,600	11,500	9,200
Finland	13,316	13,646	13,440	14,600 [r]	14,700
Georgia[e]	9,000	11,000	11,000	11,000	6,100
India	27,400	33,900	30,600	29,500 [r]	33,000
Indonesia[5]	818,000	796,900	632,600	998,530 [r]	872,300
Iran:					
Concentrates	208,000	241,000	241,000	255,000	250,000
Leaching, electrowon	9,000	8,000	8,000	7,000	7,000
Total	217,000	249,000	249,000	262,000	257,000
Kazakhstan	434,100 [r]	406,800 [r]	421,700 [r]	406,100 [r]	380,000
Korea, North[e]	12,000	12,000	12,000	12,000	12,000
Korea, Republic of	3 [r]	6 [r]	4 [r]	14 [r]	9
Laos:					
Concentrates	--	--	24,929	54,019	67,806
Leaching, electrowon	60,803	62,541	64,075	67,561	64,241
Total	60,803	62,541	89,004	121,580	132,047

See footnotes at end of table.

TABLE 20—Continued

COPPER: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Macedonia	7,000 [r]	7,400 [r]	8,400 [r]	7,600 [r]	7,900
Mauritania	5,031	31,956	33,073	35,000	37,000
Mexico:					
Concentrates	280,840 [r]	276,530 [r]	214,644 [r]	170,597	190,136
Leaching, electrowon	46,696 [r]	58,972 [r]	53,975 [r]	57,151	80,000
Total	327,536	335,502 [r]	268,619 [r]	227,748	270,136
Mongolia	129,693	130,160	126,800	129,800	126,100
Morocco	4,600	5,572	5,600	11,800 [r]	11,200
Namibia	6,262	6,580	7,471	--	--
Pakistan	19,100	18,800	18,700	18,500	18,000
Papua New Guinea	194,355	169,184	159,650	166,700	159,800
Peru:					
Concentrates	874,601	1,018,156	1,107,789	1,113,449 [r]	1,094,184
Leaching, electrowon	173,871	172,118	160,078	162,800 [r]	153,000
Total	1,048,472	1,190,274	1,267,867	1,276,249 [r]	1,247,184
Philippines	17,161	22,862	21,235	49,060	58,412
Poland	497,000	452,000	429,000	439,000 [r]	425,400
Portugal	78,660	90,247	89,070	86,900	74,300
Romania[e, 6]	12,132 [3]	2,213 [3]	2,000 [r]	1,000 [r]	1,000
Russia[e]	725,000	740,000	750,000	676,000 [r]	703,000
Saudi Arabia	730	750 [e]	1,465	2,000	2,000 [e]
Serbia	12,000	16,500	18,800	19,000	19,000 [e]
South Africa	89,500	97,000	108,700 [r]	107,600 [r]	102,600
Spain:					
Concentrates	6,616	6,281	7,071	15,400	15,000
Leaching, electrowon	--	--	--	5,600	5,600 [e]
Total	6,616	6,281	7,071	21,000	20,600
Sweden	86,800 [r]	62,800 [r]	57,220 [r]	54,602 [r]	75,977
Tanzania, in concentrates and bullion	3,284	3,275	2,852 [r]	2,319 [r]	5,326
Turkey[e, 6]	70,000 [r]	81,000	100,000 [r]	105,000 [r]	97,000
United States:[5]					
Concentrates	667,000	665,000	801,000	705,000	679,000
Leaching, electrowon	530,000	504,000	507,000	476,000	430,000
Total	1,200,000	1,170,000	1,310,000	1,180,000	1,110,000
Uzbekistan	100,000	95,000	95,000	95,000	90,000
Zambia:					
Concentrates[e]	350,000	341,000	392,000 [r]	557,000 [r]	540,000
Leaching, electrowon[e]	124,000	168,000	163,000	140,000 [r]	150,000
Total	474,000	509,000	555,000 [r]	697,000 [r]	690,000
Zimbabwe, concentrates	2,581	2,681 [r]	2,827 [r]	3,572 [r]	4,000 [e]
Grand total	15,100,000	15,500,000	15,600,000 [r]	15,900,000	16,000,000
Of which:					
Concentrates	12,300,000	12,600,000	12,500,000 [r]	12,700,000 [r]	12,700,000
Leaching, electrowon	2,780,000 [r]	2,910,000 [r]	3,050,000 [r]	3,250,000	3,310,000

See footnotes at end of table.

TABLE 20—Continued

COPPER: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

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[e]Estimated. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table represents copper content by analysis of concentrates produced (includes cement copper, if applicable), except where otherwise noted. Table includes data available through July 28, 2011.

[3] Reported figure.

[4] Reported by Comision Chilena del Cobre. Includes recoverable copper content of nonduplicative mine and metal products produced from domestic ores and concentrates and leach production for electrowinning.

[5] Recoverable content.

[6] Excludes copper content of pyrite.

TABLE 21

COPPER: WORLD SMELTER PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2006	2007	2008	2009	2010
Armenia, primary	8,791	6,954	6,480	6,858	7,500
Australia, primary	377,000	399,000	449,000	422,000	410,000
Austria, secondary	65,900	80,200	94,200	90,800	92,200 [p]
Belgium, secondary	114,600	115,000 [e]	124,500	114,400	118,600
Botswana, primary[3]	24,255	19,996	23,146	24,382	24,000 [e]
Brazil:					
Primary	179,700	178,367	184,400 [r]	176,000	176,400
Secondary[e]	40,000	40,000	39,100 [r]	31,000	47,700
Total	219,700	218,367	223,500 [r]	207,000	224,100
Bulgaria:					
Primary	217,000	217,600	257,100	256,200	265,000
Secondary[e]	24,000	11,500	21,200	20,000	19,600
Total	241,000	229,100	278,300	276,200	284,600
Canada:					
Primary	484,675	470,713	443,798	316,510	318,000
Secondary	35,826	46,101	41,777	29,733	31,800
Total	520,501	516,814	485,575	346,243	349,800
Chile, primary	1,565,400	1,514,300	1,369,200	1,522,300	1,559,800
China:[e]					
Primary	1,920,000	2,110,000	2,500,000	2,700,000 [r]	2,800,000
Secondary	700,000	800,000	870,000	1,100,000	1,300,000
Total	2,620,000	2,910,000	3,370,000	3,800,000 [r]	4,100,000
Congo (Kinshasa), primary, electrowon	10,000 [e]	1,800	--	--	--
Finland:					
Primary	162,300	141,000	172,354	137,710	149,000 [e]
Secondary[e]	2,000	2,000	2,000	2,000	2,000
Total	164,300	143,000	174,354	139,710	151,000 [e]
Germany:					
Primary	273,800	270,200	295,000	286,300 [r]	378,700
Secondary	266,300	273,400	293,300	247,500 [r]	212,400
Total	540,100	543,600	588,300	533,800 [r]	591,100
India:					
Primary	610,000	700,000	651,000	705,100	654,000
Secondary[e]	15,000	15,000	11,000	10,000	2,000
Total	625,000	715,000	662,000	715,100	656,000
Indonesia, primary	201,200	277,100	253,300	295,900	276,800
Iran:[e]					
Primary	177,000	180,000	180,000	193,000	190,000
Secondary	65,000	70,000	68,000	67,000	90,000
Total	242,000	250,000	248,000	260,000	280,000
Japan:					
Primary	1,409,087	1,367,310	1,366,310	1,297,943	1,382,700
Secondary	219,203	245,208	259,060	243,859	260,200
Total	1,628,290	1,612,518	1,625,370	1,541,802	1,642,900
Kazakhstan, undifferentiated	426,200 [r]	392,834	392,575	369,000	370,900
Korea, North, undifferentiated[e]	15,000	15,000	15,000	15,000	15,000

See footnotes at end of table.

TABLE 21—Continued
COPPER: WORLD SMELTER PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2006	2007	2008	2009	2010
Korea, Republic of:					
Primary[e]	450,000	470,000	502,000 [r]	455,000	476,000
Secondary[e]	35,000 [r]	45,000	42,000 [r]	44,000	65,000
Total	485,000 [r]	515,000	544,000 [r]	499,000	541,000
Mexico:					
Primary	260,200	222,600	200,200	153,700	153,000 [e]
Secondary[e]	5,000	5,000	5,000	5,000	5,000
Total	265,200	227,600	205,200	158,700	158,000 [e]
Namibia, primary[e, 4]	22,000	21,000	16,271 [5]	21,500 [r, 5]	20,000
Oman, primary	20,710	13,940	11,906	12,000 [e]	14,000
Pakistan, primary[e]	23,600	18,200	17,800	17,500	17,000
Peru, primary	381,300	296,100	360,400	341,500 [r]	312,968
Philippines, primary	239,600	220,000	239,700 [r]	230,100	216,200
Poland:					
Primary	445,100 [r]	438,100	438,600	427,800 [r]	452,200
Secondary	80,000	40,000	43,900	68,800	94,300
Total	525,100 [r]	478,100	482,500	496,600 [r]	546,500
Russia:[e]					
Primary	635,000	650,000	630,000	580,000	590,000
Secondary	312,000	290,000	235,000	220,000	240,000
Total	947,000	940,000	865,000	800,000	830,000
Serbia:[e]					
Primary	40,000	30,200	31,900	32,000	35,000
Secondary	1,000	1,000	1,000	1,000	1,000
Total	41,000	31,200	32,900	33,000	36,000
Slovakia, secondary	22,000 [e]	20,600 [e]	27,500	34,200	46,500
South Africa, primary	98,900 [r]	111,900 [r]	94,800 [r]	86,900 [r]	75,900
Spain:					
Primary	263,100	249,400	256,900	261,000	236,000
Secondary[e]	6,482 [5]	6,700	3,000	4,000	19,000
Total	269,582	256,100	259,900	265,000	255,000
Sweden:					
Primary	138,800	132,500	128,500	126,000	137,000
Secondary[e]	55,000	46,500	53,800	39,600	42,000
Total	193,800	179,000	182,300	165,600	179,000
Thailand:					
Primary	25,300 [r]	11,900 [r]	--	--	--
Secondary	1,750 [r]	814 [r]	--	--	--
Total	27,050 [r]	12,714 [r]	--	--	--
Turkey, undifferentiated[e, 6]	30,000	30,000	35,000	30,000	30,000
United States, undifferentiated	501,000	617,000	574,000	597,000	601,000
Uzbekistan, undifferentiated[e]	95,000	92,000	92,000	92,000	92,000
Vietnam, primary[e]	4,800 [r, 5]	11,000 [r, 5]	2,200	6,000	8,000
Zambia, primary	290,000	224,000	232,000 [e]	334,000	490,000

See footnotes at end of table.

TABLE 21—Continued

COPPER: WORLD SMELTER PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2006	2007	2008	2009	2010
Grand total:	14,100,000	14,300,000	14,700,000	14,900,000 r	15,600,000
Of which					
Primary:					
Electrowon	10,000 e	1,800	--	--	--
Other	10,900,000 r	11,000,000 r	11,300,000 r	11,400,000 r	11,800,000
Secondary	2,070,000 r	2,150,000 r	2,240,000 r	2,370,000 r	2,690,000
Undifferentiated	1,070,000 r	1,150,000 r	1,110,000 r	1,100,000 r	1,110,000

eEstimated. pPreliminary. rRevised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] This table includes total production of smelted copper metal, including low-grade cathode produced by electrowinning methods. The smelter feed may be derived from ore, concentrates, copper precipitate or matte (primary), and (or) scrap (secondary). To the extent possible, primary and secondary output of each country is shown separately. In some cases, total smelter production is officially reported, but the distribution between primary and secondary has been estimated. Table includes data available through July 28, 2011.

[3] Copper content of nickel-copper matte exported to Norway for refining.

[4] Includes 8,000 to 10,000 metric tons per year for 2006 produced from imported toll concentrates.

[5] Reported figure.

[6] Secondary production is estimated to be about one-third of total.

TABLE 22

COPPER: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Argentina, secondary[e]	16,000	16,000	16,000	16,000	16,000
Australia, primary:					
Electrowon	52,400	42,000	53,000	23,000	14,000
Other	377,000	400,000	450,000	423,000	403,000
Total	429,400	442,000	503,000	446,000	417,000
Austria, secondary	72,600	81,400	106,700	96,200	113,700 [p]
Belgium:					
Primary[3]	238,000 [e]	228,500	233,100	220,600	216,000
Secondary	153,000	165,600	162,700	153,100	165,000
Total	391,000 [e]	394,100	395,800	373,700	381,000
Brazil:					
Primary:					
Electrowon	-- [r]	900 [r]	3,800 [r]	6,500 [r]	7,400
Other	192,700 [r]	194,380 [r]	204,375 [r]	193,899 [r]	177,800
Total	192,700 [r]	195,280 [r]	208,175 [r]	200,399 [r]	185,200
Secondary	27,000	24,000	25,633	31,000	47,700
Total, primary and secondary	219,700 [r]	219,280 [r]	233,808 [r]	231,399 [r]	232,900
Bulgaria:					
Primary	60,700 [r]	64,400 [r]	114,200 [r]	183,600	195,400
Secondary[e]	4,800 [r]	5,700 [r]	12,600 [r]	13,200	19,600
Total	65,500 [r]	70,100 [r]	126,800 [r]	196,800	215,000
Burma, electrowon	19,500	15,100	--	5,000 [r]	12,000 [e]
Canada:					
Primary	465,000	407,000	400,000	305,296	280,000
Secondary	36,000	46,000	42,000	30,600	32,000
Total	501,000	453,000	442,000	335,896	312,000
Chile, primary:					
Electrowon	1,691,800	1,832,100	1,971,000	2,117,500 [r]	2,088,500
Other	1,119,500	1,104,400	1,086,600	1,159,100	1,155,400
Total	2,811,300	2,936,500	3,057,600	3,276,600 [r]	3,243,900
China:[e]					
Primary:					
Electrowon	20,000	20,000	20,000	17,000 [r]	35,000
Other	2,000,000	2,280,000	2,680,000	2,750,000	2,950,000
Total	2,020,000	2,300,000	2,700,000	2,770,000 [r]	2,990,000
Secondary	1,000,000	1,200,000	1,200,000	1,400,000	1,700,000
Total, primary and secondary	3,020,000	3,500,000	3,900,000	4,170,000 [r]	4,690,000
Congo (Kinshasa), electrowon	--	6,897 [r]	38,632 [r]	154,671 [r]	235,204
Cyprus, electrowon	1,000	2,900	2,986	2,380	2,400 [e]
Egypt, secondary	1,719 [r]	2,664 [r]	2,842 [r]	3,000 [r]	3,000 [e]
Finland:					
Primary	120,674	100,987	127,952	95,549	112,000 [e]
Secondary[e]	16,000	10,000	10,000	10,000	10,000
Total	136,674	110,987	137,952	105,549	122,000 [e]
Germany:					
Primary	312,092	301,702	300,470	290,200	346,300 [p]
Secondary	350,246	363,815	389,300	378,745 [r]	347,300 [p]
Total	662,338	665,517	689,770	668,945 [r]	693,600 [p]

See footnotes at end of table.

TABLE 22—Continued
COPPER: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Hungary, secondary[e]	10,000	10,000	--	--	--
India:					
Primary, electrolytic	614,000	698,600	654,200	705,100	654,900
Secondary[e]	15,000	15,000	15,000	10,000	2,000
Total	629,000	713,600	669,200	715,100	656,900
Indonesia, primary	217,600	277,000	254,000	289,200	278,200
Iran:					
Primary:[e]					
Electrowon	9,000	8,000	7,000	7,000	7,000
Other	140,000	141,000[r]	140,000	150,000	143,000
Total	149,000	149,000[r]	147,000	157,000	150,000
Secondary	51,000[r]	52,000[r]	53,000	53,000	70,000
Total, primary and secondary	200,000[r]	201,000[r]	200,000	210,000	220,000
Italy, secondary[e]	36,400[4]	28,600[4]	24,200	6,500	6,500
Japan:					
Primary	1,342,350	1,369,814	1,328,157	1,238,012	1,333,800
Secondary	189,705	207,004	211,681	201,831	214,900
Total	1,532,055	1,576,818	1,539,838	1,439,843	1,548,700
Kazakhstan, primary	427,723	406,091	398,411[r]	368,113[r]	323,428
Korea, North, primary[e]	15,000	15,000	15,000	15,000	15,000
Korea, Republic of:					
Primary	541,500[r]	536,467[r]	492,925[r]	441,401[r]	467,600
Secondary	34,000	45,000	45,000[r]	90,300[r]	97,000
Total	575,500[r]	581,467[r]	537,925[r]	531,701[r]	564,600
Laos, electrowon	60,803	62,541	64,075[r]	67,561[r]	64,241
Mexico:					
Primary:					
Electrowon	89,076	107,000	74,500	65,700[e]	80,000[e]
Other	284,300	238,900	215,500	190,000[e]	192,600
Total	373,376	345,900	290,000	255,700	272,600
Secondary[e]	6,000	6,000	6,000	5,000	5,000
Total, primary and secondary	379,376	351,900	296,000	260,700	277,600
Mongolia, electrowon	2,618	3,007	2,587	2,470	2,750
Norway, primary[5]	38,500[e]	43,000	32,000	30,000	30,000
Oman, primary	21,000	14,000	12,000	12,000	14,000
Peru, primary:					
Electrowon	173,871	172,118	160,078	157,082[r]	153,022
Other	333,839	241,789	303,855	260,618[r]	240,616
Total	507,710	413,907	463,933	417,700[r]	393,638
Philippines, primary	181,000	160,200	174,600[r]	178,000[r]	171,900
Poland:					
Primary	476,100	493,200	483,000	433,600[r]	452,700
Secondary	80,500	39,800	43,800[r]	68,800[r]	94,300
Total	556,600	533,000	526,800[r]	502,400[r]	547,000

See footnotes at end of table.

TABLE 22—Continued
COPPER: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Romania:					
Primary	18,583	15,584	10,323	3,000 [r]	3,000 [e]
Secondary[e]	3,000	3,000	3,000	1,000 [r]	1,000
Total	21,583	18,584	13,323	4,000 [r]	4,000 [e]
Russia:					
Primary	635,000	650,000	610,000	612,000 [r]	656,000
Secondary	312,000	289,000	250,000	250,000 [r]	218,000
Total	947,000	939,000	860,000	862,000 [r]	874,000
Serbia:					
Primary	40,000	30,600	32,800	33,000	34,000
Secondary[e]	1,000	1,000	1,000	1,000	1,000
Total	41,000	31,600	33,800	34,000	35,000
South Africa, primary[5]	104,052	113,166	92,972	89,451	82,202
Spain:					
Primary:					
Electrowon	--	--	--	5,600 [r]	28,500
Other	235,300	243,000	257,000	250,200 [r]	236,000
Total	235,300	243,000	257,000	255,800 [r]	264,500
Secondary[e]	64,000	65,000	62,000	73,000 [r]	82,900
Total, primary and secondary	299,300	308,000	319,000	328,800 [r]	347,400
Sweden:					
Primary	187,800	175,500	184,674	164,759	150,497
Secondary	41,200	38,500	43,100	41,000	40,000 [e]
Total	229,000	214,000	227,774	205,759	190,497
Taiwan, secondary[e]	4,500	4,500	4,500	4,500	4,500
Thailand:					
Primary	25,300	11,900	--	--	--
Secondary	1,750	814	438	490 [r]	500
Total	27,050	12,714	438	490 [r]	500
Turkey:[e]					
Primary	101,000	94,600	83,000	30,000	50,000
Secondary	5,000	5,000	5,000	4,000	5,000
Total	106,000	99,600	88,000	34,000	55,000
Ukraine, secondary[e]	20,000	20,000	20,000	20,000	20,000
United States:					
Primary:					
Electrowon	530,000	504,000	507,000	476,000	430,000
Other	675,000	764,000	713,000	636,000	627,000
Total	1,210,000	1,270,000	1,220,000	1,110,000	1,060,000
Secondary	44,800	46,000	53,800	46,400	37,700
Total, primary and secondary	1,250,000	1,310,000	1,270,000	1,160,000	1,090,000
Uzbekistan, primary	92,300	89,655	71,000	80,000	90,000
Vietnam, primary	--	--	--	6,000 [e]	6,000 [e]
Zambia, primary:[e]					
Electrowon[6]	178,000	200,000	175,000	145,400 [4]	160,000
Other	240,000	230,000	240,000	269,000 [4]	370,000
Total	418,000	430,000	415,000	414,400 [4]	530,000

See footnotes at end of table.

TABLE 22—Continued

COPPER: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Zimbabwe, primary[e]	7,000	6,798 [4]	3,072 [4]	3,000	5,000
Grand total	17,300,000	17,900,000	18,300,000	18,400,000	19,100,000
Of which:					
Primary:					
Electrowon	2,830,000	2,980,000	3,080,000	3,250,000	3,320,000
Other	11,900,000	12,100,000 [r]	12,400,000	12,100,000 [r]	12,500,000
Total	14,700,000	15,100,000	15,500,000	15,400,000	15,800,000
Secondary	2,600,000 [r]	2,790,000 [r]	2,810,000 [r]	3,010,000 [r]	3,350,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] This table includes total production of refined copper whether produced by pyrometallurgical or electrolytic refining methods and whether derived from primary unrefined copper or from scrap. Copper cathode derived from electrowinning processing is also included. Table includes data available through July 28, 2011.

[3] Includes reprocessed leach cathode from Congo (Kinshasa).

[4] Reported figure.

[5] May include secondary.

[6] Electrowon covers only high-grade electrowon cathodes reported as "finished production leach cathodes."

DIAMOND, INDUSTRIAL

By Donald W. Olson

Domestic survey data and tables were prepared by Connie Lopez, statistical assistant, and the author. The world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2010, U.S. synthetic diamond production was estimated to be 93.0 million carats (Mct) with an estimated value of $66.4 million. U.S. imports of all forms of industrial diamond totaled about 597 Mct valued at almost $119 million, while exports totaled more than 113 Mct valued at almost $52.8 million. The estimated U.S. apparent consumption of all forms of industrial diamond was 612 Mct with an estimated value of $150 million. Total industrial diamond output worldwide was estimated by the U.S. Geological Survey (USGS) to be about 4.45 billion carats valued between $1.65 and $2.50 billion. This was the combination of more than 63.8 Mct natural industrial diamond and about 4.38 billion carats synthetic industrial diamond.

Diamond is best known as a gemstone, but some of its unique properties make it ideal for many industrial and research applications as well. Current information on gem-grade diamond can be found in the USGS Minerals Yearbook, volume I, Metals and Minerals, chapter on gemstones. Diamond that does not meet gem-quality standards for clarity, color, shape, or size is used as industrial-grade diamond. Production and consumption quantities and values reported are estimated to avoid disclosing company proprietary data and still provide useful data on the overall market. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data. The USGS does not conduct surveys of either domestic polycrystalline diamond (PCD) producers or domestic chemical vapor deposition (CVD) diamond producers for quantity or value of annual production. Also, trade and consumption quantity or value data are not available for PCD or for CVD diamond.

Production

The USGS conducts an annual survey of domestic industrial diamond producers and U.S. firms that recover diamond wastes. Although most of these companies responded to the 2010 survey, one of the three industrial diamond recycling firms did not report data that they deemed to be proprietary. To protect the proprietary data of other producers and recyclers, only estimates of U.S. primary and secondary output are provided in this review.

As one of the world's leading producers of synthetic industrial diamond, the United States accounted for an estimated output of 93 Mct valued at more than $66.4 million in 2010. Only two U.S. companies produced synthetic industrial diamond during the year—Diamond Innovations, Inc. (Worthington, OH) and Mypodiamond, Inc. (Smithfield, PA).

In 2010, at least eight U.S. companies also manufactured PCD from synthetic diamond grit and powder. These companies were Dennis Tool Co. (Houston, TX), Diamond Innovations, Novatek Inc. (Provo, UT), Precorp Inc. (Provo), Sii MegaDiamond Inc. (Provo), Tempo Technology Corp. (Somerset, NJ), US Synthetic Corp. (Orem, UT), and Western Diamond Products LLC (Salt Lake City, UT).

During 2010, an estimated 33.8 Mct of used industrial diamond worth about $17.3 million was recycled in the United States. Recycling firms recovered most of this material from used diamond drill bits, diamond tools, and other diamond-containing wastes. Additional diamond was recovered during the year from residues generated in the manufacture of PCD; most of this material was recovered from within the production operations of the PCD-producing companies.

The recovery and sale of industrial diamond was the principal business of three U.S. companies in 2010—Industrial Diamond Laboratory, Inc. (Bronx, NY), International Diamond Services Inc. (Houston, TX), and National Research Co. (Fraser, MI). In addition to these companies, other domestic firms may have recovered industrial diamond in smaller secondary operations.

There were no commercially operated diamond mines in the United States during 2010. The last commercially operated diamond mine in the United States closed in 2002 and was fully reclaimed.

Consumption

Diamond is the hardest known material and has the highest thermal conductivity of any material at room temperature. Diamond is more than twice as hard as its nearest competitors, cubic boron nitride and silicon nitride. Because it is the hardest substance known, diamond has been used for centuries as an abrasive in cutting, drilling, grinding, and polishing. Industrial-grade diamond continues to be used as an abrasive for many applications. Even though it has a higher unit cost, diamond has proven to be more cost-effective in many industrial processes because it cuts faster and lasts longer than alternative abrasive materials (Boucher, 1997, p. 26.6). Diamond also has chemical, electrical, optical, and thermal characteristics that make it the best material available to industry for wear- and corrosion-resistant coatings, special lenses, heat sinks in electrical circuits, wire drawing, computing, and other advanced technologies.

Both synthetic and natural diamonds have industrial uses. Synthetic industrial diamond is superior to its natural diamond counterpart because its properties can be tailored to specific applications, and it can be produced in large quantities (Boucher, 1996). For these reasons, synthetic diamond accounts for about 94% of the industrial diamond used in the United States and about 99% of the industrial diamond used in the world.

The United States remained the world's leading market for industrial diamond in 2010. Based on production estimates and trade data, U.S. apparent consumption of industrial diamond during the year increased 100% to an estimated 612 Mct valued at $150 million compared with 305 Mct valued at $109 million in 2009. This apparent consumption was the combination of

556 Mct of diamond bort, grit, dust, and powder valued at $63.2 million and 55.9 Mct of diamond stone valued at $86.5 million. These large increases were owing to industrial sectors that consume industrial diamond beginning to recover from the negative impacts of the economic recession.

The major consuming industries of industrial diamond in the United States during 2010 were construction, machinery manufacturing, mining services (exploration drilling for minerals, natural gas, and oil), stone cutting/polishing, and transportation systems (infrastructure and vehicles). Within these sectors, stone cutting and highway building/repair together made up the largest demand for industrial diamond. Research and high-technology uses included close-tolerance machining of ceramic parts for the aerospace industry, heat sinks in electronic circuits, lenses for laser radiation equipment, polishing of silicon wafers and disk drives, and other applications in the computer industry.

Diamond tools have numerous industrial functions. Diamond drilling bits and reaming shells are used principally for minerals, natural gas, and oil. Other applications of diamond bits and reaming shells include foundation testing, masonry drilling, and inspecting concrete. The primary uses of point diamond tools are for dressing and truing grinding wheels and for boring, cutting, finishing, and machining applications. Beveling glass for automobile windows is another application. Cutting dimension stone and cutting/grooving concrete in highway reconditioning are the main uses of diamond saws; other applications include cutting composites and forming refractory shapes for furnace linings. Very fine diamond saws are used to slice brittle metals and crystals into thin wafers for electronic and electrical devices. Diamond wire dies are essential for high-speed drawing of fine wire, especially from hard, high-strength metals and alloys. The primary uses of diamond grinding wheels include edging plate glass, grinding dies, grinding parts for optical instruments, and sharpening and shaping carbide machine tool tips.

Two types of natural diamond are used by industry—diamond stone (generally larger than 60 mesh/250 micrometers) and diamond bort (smaller, fragmented material). Diamond stone is used mainly in drill bits and reaming shells used by mining companies; it also is incorporated in single- or multiple-point diamond tools, diamond saws, diamond wheels, and diamond wire dies. Diamond bort is used for drill bits and as a loose grain abrasive for polishing. Other tools that incorporate natural diamond include bearings, engraving points, glass cutters, and surgical instruments.

Synthetic diamond grit and powder are used in diamond grinding wheels, saws, impregnated bits and tools, and as a loose abrasive for polishing. Diamond grinding wheels can be as large as 1 meter in diameter.

Loose powders made with synthetic diamond for polishing are used primarily to finish cutting tools, gemstones, jewel bearings, optical surfaces, silicon wafers, and wire-drawing dies for computer chips. Hundreds of other products made from ceramics, glass, metals, and plastics also are finished with diamond powders.

Two types of PCDs used by industry are polycrystalline diamond compacts (PDCs) and polycrystalline diamond shapes (PDSs). The use of PDCs and PDSs continues to increase for many of the applications cited above, including some of those that employ natural diamond. The use of PDCs, PDSs, and matrix-set synthetic diamond grit for drilling bits and reaming shells has increased in recent years. PDCs and PDSs are used in the manufacture of single- and multiple-point tools, and PDCs are used in a majority of the diamond wire-drawing dies.

Since its introduction in the mid-1980s, CVD diamond has seen strong growth and is presently being accepted by multiple industries as an enhanced material of choice owing to its properties of exceptional strength, durability, stiffness, high thermal conductivity, and electrical isolation. The global market value of industrial diamond and diamond-like films and coatings was estimated to have been $905 million in 2010, and is expected to increase to more than $1.7 billion in 2015.

Early applications for CVD diamond focused largely around thin- and thick-film PCD for cutting tools and dressing applications because of the mechanical properties of diamond. Newer applications that take advantage of CVD diamond's mechanical properties include wear parts, such as watch gears and chemical mechanical polishing pad conditioners. Diamond has tremendous potential for electronics applications because it significantly improves upon current strategies for thermal management while remaining highly cost-competitive with other approaches. CVD diamond is used in microelectronic components, such as high-speed processors, medical devices, wide bandgap radio frequency (RF) devices, power conversion devices, and opto-electronic devices (light emitting diodes, laser diodes) that generate exceptionally high heat densities requiring innovative approaches to thermal management. In the manufacture of semiconductors, wafer scale diamond offers enhanced mechanical properties, such as significantly higher stiffness, strength, hardness, thermal conductivity, and chemical inertness than silicon and most other thin-film materials, which are commonly used. Diamond coatings are finding increasing use in electronic applications because of the high thermal conductivity of diamond (10 times that of silicon). Micro-electro-mechanical systems (MEMS), such as RF MEMS resonators, have design needs that offer a compelling case for the use of diamond as a base material as a result of superior properties (high Young's Modulus and its durability in harsh environments). Researchers are investigating the use of boron-doped diamond (BDD) electrodes for water treatment owing to diamond's potential as an environmentally friendly, high performance electrode material. BDD electrodes have many characteristics that make them ideal for eliminating organic contaminants from water (Zimmer, 2011).

Historically, diamond has been perceived as an expensive material. Advances in CVD diamond manufacturing like the development of microwave carbon plasma technology and the development of higher-throughput hot filament (HF) CVD diamond reactors have significantly reduced diamond costs. This led many industries to revisit development activities and actively pursue the use of CVD diamond for a growing number of applications (Zimmer, 2011).

Prices

Pricing of natural diamond was driven up by strong demand at auctions held in all of the global diamond centers. This has affected prices of industrial diamond as well as gemstone diamond. These price increases were a reflection of strong demand for the whole range of rough diamonds for industrial markets (Roffman, 2011).

Natural and synthetic industrial diamonds differ significantly in price. Natural industrial diamond normally has a more limited range of values, from about $0.49 per carat for bort size material to about $2.50 to $10 per carat for most stones, with some larger stones selling for $200 per carat or more. Prices of synthetic diamond vary according to size, shape, crystallinity, and the absence or presence of metal coatings. In general, prices for synthetic diamond for grinding and polishing range from as low as $0.26 per carat to $2.50 per carat. Strong and blocky material for sawing and drilling sells for $2.50 to $4.00 per carat. Large, synthetic crystals with excellent structure for specific applications sell for several hundred dollars per carat. During 2010, U.S. imports of all types of industrial diamond had an average value of $0.20 per carat. These imports were a combination of imports of diamond bort, grit, and dust and powder (natural and synthetic) that had an average value of $0.15 per carat and imports of diamond stone (natural and synthetic) that had an average value of $18.80 per carat.

Foreign Trade

The United States continued to lead the world in industrial diamond trade in 2010; imports were received from 33 countries and exports and reexports were sent to 35 countries (tables 1–4). Although the United States has been a major producer of synthetic diamond for decades, expanding domestic markets have become more reliant on foreign sources of industrial diamond in recent years. U.S. markets for natural industrial diamond have always been dependent on imports and secondary recovery operations because there has been no domestic production of natural diamond.

During 2010, U.S. imports of industrial-quality diamond stones (natural and synthetic) increased by 23% from those of 2009 to about 1.72 Mct valued at about $32.3 million (table 1). The average value of these industrial-quality diamond stone imports was $18.80 per carat. Imports of diamond dust, grit, and powder (natural and synthetic) more than doubled from those of 2009 to 596 Mct valued at about $86.5 million (table 2). The average value of these industrial diamond dust, grit, and powder imports was $0.15 per carat.

Reexports account for a significant portion of total exports/reexports; therefore, exports and reexports are listed separately in tables 3 and 4 so that U.S. trade and consumption can be calculated more accurately. During 2010, the United States did not export industrial diamond stones, unchanged from 2009. U.S. reexports of industrial diamond stone increased by 14% from those of 2009 to 1.08 Mct valued at $23.4 million and an average value of $21.60 per carat (table 3). U.S. exports of industrial diamond dust, grit, and powder (natural and synthetic) increased by 68% from those of 2009 to 113 Mct valued at $52.8 million and an average value of $0.47 per carat. Reexports of industrial diamond dust, grit, and powder (natural and synthetic) increased by 85% from those of 2009 to 18.2 Mct valued at $8.73 million and an average value of $0.48 per carat (table 4).

World Industry Structure

In 2010, industrial diamond was produced in 28 countries (tables 5, 6). Total industrial diamond output worldwide was estimated by the USGS to be about 4.45 billion carats valued between $1.65 and $2.50 billion. Natural industrial diamond production worldwide was estimated to be more than 63.8 Mct, a 15% increase compared with that of 2009. Congo (Kinshasa) was the leading producing country, followed by Russia and Australia, in descending order of quantity. These three countries produced more than 74% of the world's natural industrial diamond (table 5). Synthetic industrial diamond production worldwide was estimated to be more than 4.38 billion carats, a slight increase compared with that of 2009. China was the leading producing country, followed by the United States, Russia, Ireland, and South Africa, in descending order of quantity. These five countries produced about 98% of the world's synthetic industrial diamond (table 6).

In addition to the countries listed in table 6, Germany and the Republic of Korea produced synthetic diamond, but specific data on their output could not be confirmed. In 2010, 97% of the total global natural and synthetic industrial diamond output was produced in China, Ireland, Russia, South Africa, and the United States. Synthetic diamond accounted for more than 99% of global diamond production and consumption.

World Review

Global diamond production increased 10% during 2010 to 144 Mct. The world's leading rough diamond producers, in decreasing order of quantity produced, were: Russia, producing 32.8 Mct or 23% of total world production; Botswana, with 32.0 Mct (22%); Congo (Kinshasa), with 27.7 Mct (19%); Angola, with 13.8 Mct (10%); Canada, with 11.8 Mct (8%); Australia, with 10.0 Mct (7%); South Africa, with 8.9 Mct (6%); and other countries, with 6.76 Mct (5%) (table 5).

Worldwide diamond exploration allocations decreased 9% in 2010, to $357 million spent by 99 companies compared with $393 million by 113 companies during the previous year. This lowered the diamond share of overall worldwide exploration spending to 3% during 2010. Planned diamond exploration spending in 2010 was the least budgeted since 2003. Africa was the most popular diamond exploration location for the seventh year in a row, although Africa's share of overall exploration spending decreased to 35% in 2010 from almost 50% in 2009. Canada's share of total diamond exploration budgets increased to 29% in 2010 from 18% in 2009. De Beers Group dropped from the position of top diamond explorer that it had held for well over a decade, and was replaced by ALROSA Co. Ltd. ALROSA, De Beers Group, and Rio Tinto plc were the three leading diamond exploring companies, accounting for 57% of the estimated $357 million total global diamond exploration budget in 2010 (Metals Economics Group, 2010, p. 8–9; 2011, p. 13).

Worldwide in 2010, diamond prices recovered strongly from the downturn caused by the global recession. The recovery was led by an upturn in the U.S. markets; this was demonstrated by increasing quantity and value of diamond imports in 2010 and improved sales in North America overall (Metals Economics Group, 2011, p. 10).

Worldwide in 2010, three diamond mines started up, including one mine reopening. One of the startups was in Botswana, one in Brazil, and the reopening was in South Africa (Metals Economics Group, 2011, p. 15).

Botswana.—Firestone Diamonds plc received a license for mining the BK11 Mine in July 2010, and began operating phase I of the production plant. Work on phase 2 was completed in the third quarter of 2010, increasing the ore production rate to 1.5 million tons per year. The mine reached full production of 150,000 carats per year in the fourth quarter 2010. The BK11 Mine is an open pit operation, which is 90% owned by Firestone Diamonds plc and 10% by a local company. Firestone estimated the BK11 mine's reserves to be 18.0 million tons (Mt) at start up (Metals Economics Group, 2011, p. 15).

Brazil.—During the third quarter 2010, Vaaldiam Mining Inc. started production at its Duas Barras alluvial mining operation. Diamond recovery during the quarter was 643 carats from ore grading 0.03 carats per cubic meter. The ore grade improved after September with the opening of a second mining front that exposed large amounts of better quality gravels. The recovered diamond grade was approximately 0.16 carats per cubic meter. Vaaldiam estimated the reserves to be 2.3 Mt for Duas Barras (Metals Economics Group, 2011, p. 15).

Canada.—Canadian diamond production was about 11.8 Mct during 2010, an increase of about 8% compared with that of 2009. Diamond exploration continued in Canada, with several commercial diamond projects and additional discoveries in Alberta, British Columbia, the Northwest Territories, the Nunavut Territory, Ontario, and Quebec. In 2010, Canada produced 8.2% of the world's combined natural gemstone and industrial diamond output.

The Ekati Diamond Mine, Canada's first operating commercial diamond mine, completed its twelfth full year of production in 2010. Ekati produced 2.89 Mct of diamond from 4.85 Mt of ore. BHP Billiton Ltd. has an 80% controlling ownership in Ekati, which is in the Northwest Territories. Ekati has estimated remaining reserves of 38.5 Mt of ore in kimberlite pipes that contain 18.3 Mct of diamond. BHP Billiton projected the remaining mine life to be 12 years. Approximately 21% of the Ekati 2010 diamond production is industrial-grade material (BHP Billiton Ltd., 2011, p. 10; Perron, 2011, p. 1).

The Diavik Diamond Mine, Canada's second diamond mine, also located in the Northwest Territories, completed its eighth full year of production. In 2010, Diavik produced 6.5 Mct of diamond, an increase of 16% from the previous year's production. At yearend 2010, Diavik estimated the mine's remaining proven and probable reserves to be 18 Mt of ore in kimberlite pipes containing 52.2 Mct of diamond and projected the total mine life to be 16 to 22 years. Diavik began developing an underground mine and substantially completed construction on the project during 2009. The first ore was produced from the underground mine during the first quarter of 2010, with full production expected in 2013. The mine is an unincorporated joint venture between Diavik Diamond Mine Inc. (60%) and Harry Winston Diamond Mines Ltd. (40%) (Diavik Diamond Mine Inc., 2011; Perron, 2011, p. 2).

Canada's third diamond mine, the Jericho Diamond Mine, is located in Nunavut and was originally owned by Tahera Diamond Corp. Tahera estimated the Jericho Diamond Mine's reserves to be about 5.5 Mt of ore grading 0.85 carats per ton. The Jericho Diamond Mine experienced startup problems related to ore mining and processing. The mine also suffered financial problems owing to the cost of transporting supplies to the mine site, high operational costs, high oil prices, and appreciation of the Canadian dollar versus the U.S. dollar. All of these problems combined to force the company to enter into protection under Canada's "Companies' Creditors Arrangement Act" on January 16, 2008, and the mine suspended production on February 6, 2008. At yearend 2009, Tahera was finalizing arrangements to sell all of its Jericho Mine assets (Perron, 2011, p. 2). In July 2010, Shear Minerals Ltd. (now known as Shear Diamonds Ltd.) announced that it had entered into a purchase agreement with Tahera and Benachee Resources Inc. to acquire a 100% interest in the Jericho Diamond Mine, the mine's processing facilities, and all supporting exploration assets in the Kitikmeot region of Nunavut (Shear Minerals Ltd., 2010). Shear Minerals completed the acquisition of the Jericho Diamond Mine in August 2010 with the intention of bringing the mine back into production (Shear Minerals Ltd., 2011).

The Snap Lake Mine, which is wholly owned by De Beers Canada Inc., is in the Northwest Territories. The Snap Lake deposit is a tabular-shaped kimberlite dyke rather than the typical kimberlite pipe. The dyke is 2.5 meters thick and dips at an angle of 12° to 15°. The deposit was mined using a modified room and pillar underground mining method in 2010. The Snap Lake Mine started mining operations in October 2007, reached commercial production levels in the first quarter of 2008, and officially opened June 25, 2008. The mine was expected to produce 1.4 Mct per year of diamond, and the mine life was expected to be about 20 years. The mine's production for 2010 amounted to 926,000 carats for a recovered grade of 1.2 carats per ton (De Beers Canada Inc., 2011; Perron, 2011, p. 2–3).

The Victor Mine, which also is wholly owned by De Beers Canada, is in northern Ontario on the James Bay coast. The Victor kimberlite consists of two pipes with surface area of 15 hectares (37.1 acres). The Victor Mine initiated mining operations at the end of December 2007 and was officially opened on July 26, 2008. The Victor reportedly has 27.4 Mt of ore with average ore grade of 0.23 carats per ton estimated minable reserves. At full capacity, the open pit mine was expected to produce 600,000 carats per year, and the mine life was expected to be about 12 years. In 2010, the mine's production was 826,000 carats recovered from 2.67 Mt of ore (De Beers Canada Inc., [undated]; Perron, 2011, p. 3).

South Africa.—In 2007, Petra Diamonds Ltd. bought the Kimberley diamond operations from De Beers for $11 million. After completing the mine rehabilitation, Petra reopened the underground mine in September 2010. Petra had been producing from tailings and stockpile for the previous few years. During the fourth quarter 2010, Kimberley produced 25,000 carats grading 0.14 carats per ton, and sold 17,300 carats for an average price of $285 per carat. The Kimberley Mine is 74%

owned by Petra Diamonds Ltd. and 26% by Sedibeng. Petra estimated the Kimberley Mine's reserves to be 57.0 million tons. Kimberley's production was expected to be 100,000 carats from the processing of 1 million tons per year of ore (Metals Economics Group, 2011, p. 15).

Outlook

China is expected to remain the world's leading producer of synthetic industrial diamond, with annual production exceeding 4 billion carats. The United States is likely to continue to be one of the world's leading markets for industrial diamond into the next decade and likely will remain a significant producer and exporter of synthetic industrial diamond as well. U.S. industrial diamond production, imports, and apparent consumption is expected to continue to increase as manufacturing sectors that use industrial diamond recover from the negative impact of the economic recession that started in mid-2008. U.S. demand for industrial diamond is likely to continue in the construction sector as the United States continues building and repairing the Nation's highway system.

Diamond offers many advantages for precision machining and longer tool life. In fact, even the use of wear-resistant diamond coatings to increase the life of materials that compete with diamond is a rapidly growing application. Increased tool life not only leads to lower costs per unit of output but also means fewer tool changes and longer production runs (Advanced Materials & Processes, 1998). In view of the many advantages that come from increased tool life and reports that diamond film surfaces can increase durability by a factor of 50, much wider use of diamond as an engineering material is expected.

PCD for abrasive tools and wear parts are likely to continue to replace competing materials in many industrial applications by providing closer tolerances as well as extending tool life. For example, PDCs and PDSs will continue to displace natural diamond stone and tungsten carbide products used in the drilling and tooling industries.

CVD technology can produce extremely pure diamond crystals that have great potential in computer technology in the production of diamond computer chips when their cost becomes competitive. These diamond computer chips will work at a much higher frequency or faster speed and can be placed in a higher-temperature environment than the silicon chips currently used in computers. Eventually, they may replace silicon chips in computers. CVD diamonds annealed using the low-pressure/high-temperature microwave plasma process may have applications such as using the diamond crystals in high-pressure research, optical applications that take advantage of the outstanding transparency of diamond, or using them in quantum computing to store quantum information in vacancy centers in the diamond's crystal lattice.

Truing and dressing applications will remain a major domestic end use for natural industrial diamond stone. Stones for these applications have not yet been manufactured economically. No shortage of the stone is anticipated, however, because new mines and more producers selling in the rough diamond market will maintain ample supplies. More competition introduced by the additional sources also may temper price increases.

Demand for synthetic diamond bort, grit, and dust and powder is expected to remain greater than for natural diamond material. Constant-dollar prices of synthetic diamond products probably will continue to decline as production technology becomes more cost effective; the decline is even more likely if competition from low-cost producers in China and Russia continues to increase.

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TABLE 1
U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL DIAMOND STONES, BY COUNTRY[1]

(Thousand carats and thousand dollars)

Country	Natural industrial diamond stones[2]				Miners' diamond, natural and synthetic[3]			
	2009		2010		2009		2010	
	Quantity	Value[4]	Quantity	Value[4]	Quantity	Value[4]	Quantity	Value[4]
Australia	52	390	42	288	(5)	40	9	74
Belgium	9	164	23	321	(5)	30	(5)	21
Botswana	678	10,400	835	19,800	3	13	11	47
Congo (Kinshasa)	10	209	7	111	--	--	2	7
Ghana	(5)	5	(5)	11	--	--	(5)	3
India	40	39	77	218	11	146	3	350
Namibia	129	856	219	1,340	1	6	--	--
Russia	137	2,140	210	4,540	--	--	(5)	5
South Africa	295	3,540	234	4,140	7	118	26	266
Other	30	466	13	663	(5)	71	10	133
Total	1,380	18,200	1,660	31,400	22	424 [r]	61	906

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes glazers' and engravers' diamond unset, Harmonized Tariff Schedule of the United States (HTS) codes 7102.21.3000 and 7102.21.4000.

[3] HTS codes 7102.21.1010 and 7102.21.1020.

[4] Customs value.

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 2

U.S. IMPORTS FOR CONSUMPTION OF DIAMOND DUST, GRIT, AND POWDER, BY COUNTRY[1]

(Thousand carats and thousand dollars)

	Synthetic[2]				Natural[2]			
	2009		2010		2009		2010	
Country	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]
Belgium	709	297	1,540	353	20	12	121	79
China	174,000	13,500	461,000	35,800	142	65	1,050	430
Germany	64	34	53	39	--	--	24	22
Hong Kong	504	157	638	218	--	--	10	5
India	759	384	854	439	744	442	1,470	818
Ireland	44,900	17,900	66,200	28,800	637	359	688	399
Israel	--	--	445	423	--	--	--	--
Italy	9	2	14	14	--	--	--	--
Japan	1,670	922	2,540	1,970	16	46	--	--
Korea, Republic of	7,850	1,790	22,700	7,600	4	7	25	6
Macau	13	9	--	--	--	--	--	--
Mexico	--	--	--	--	--	--	89	59
Romania	1,240	265	13,200	1,540	--	--	--	--
Russia	7,700	1,470	15,500	2,700	15	17	--	--
Switzerland	1,000	1,360	3,130	2,770	231	135	548	180
Taiwan	61	15	55	15	--	--	--	--
Ukraine	327	29	176	29	--	--	--	--
United Arab Emirates	--	--	243	170	--	--	--	--
United Kingdom	1,790	761	1,710	636	886	478	559	384
Other	170	140	451	169	147	401 r	163	384
Total	243,000	39,100	591,000	83,700	2,840	1,960 r	4,750	2,770

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States codes 7105.10.0020, 7105.10.0030, and 7105.10.0050 for synthetic and 7105.10.0011 and 7105.10.0015 for natural.

[3] Customs value.

Source: U.S. Census Bureau.

TABLE 3
U.S.REEXPORTS OF INDUSTRIAL DIAMOND STONES, BY COUNTRY[1]

(Thousand carats and thousand dollars)

	Industrial unworked diamonds[2]			
	2009		2010	
Country	Quantity	Value[3]	Quantity	Value[3]
Reexports:				
Belgium	341	4,720	417	6,680
Brazil	12	87	39	195
Canada	95	670	152	993
Germany	11	326	11	359
Hong Kong	114	1,690	49	695
Israel	131	1,140	26	131
Japan	92	4,390	145	8,230
Korea, Republic of	17	860	25	1,430
South Africa	14	10	--	--
United Arab Emirates	16	517	(4)	10
United Kingdom	67	2,270	72	2,410
Other	38	815 r	147	2,270
Total	948 r	17,500	1,080	23,400

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States code 7102.21.0000.

[3] Customs value.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
U.S. EXPORTS AND REEXPORTS OF INDUSTRIAL DIAMOND DUST, GRIT, AND POWDER, BY COUNTRY[1]

(Thousand carats and thousand dollars)

	Synthetic[2]				Natural[2]			
	2009		2010		2009		2010	
Country	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]	Quantity	Value[3]
Exports:								
Austria	470	207	1,790	622	--	--	--	--
Belgium	253	61	368	90	15	6	--	--
Brazil	3,260	1,080	5,530	1,660	11	5	2	5
Canada	2,950	1,970	4,010	3,190	191	440	216	681
Germany	1,600	524	3,490	1,200	22	20	9	7
Greece	255	45	--	--	--	--	--	--
Hong Kong	15	11	40	35	36	107	4	10
India	2,410	998	2,790	1,050	59	44	2	7
Ireland	16,000	5,660	25,300	8,780	47	76	25	74
Israel	4	5	50	33	--	--	516	165
Italy	4,010	1,350	3,910	1,290	--	--	--	--
Japan	10,100	4,970	29,000	13,800	23	58	7	9
Korea, Republic of	6,010	3,550	7,240	3,770	20	14	71	13
Mexico	216	76	366	164	259	125	443	208
Singapore	745	1,660	846	2,480	14	42	--	--
Spain	199	44	68	14	--	--	--	--
Switzerland	6,580	4,820	7,460	5,630	205	124	554	290
Taiwan	2,340	982	4,340	1,710	27	17	26	8
Thailand	3,880	1,280	5,100	1,540	4	3	--	--
United Kingdom	2,460	819	3,630	1,250	212	202	401	224
Other	1,810	975	4,850	2,720	369	998	58	80
Total	65,500	31,100	110,000	51,000	1,510	2,280	2,330	1,780
Reexports:								
Belgium	74	33	35	39	81	192	119	228
Brazil	557	117	792	229	--	--	--	--
Canada	2,180	1,220	7,150	4,120	24	81	118	433
Germany	10	22	11	8	11	32	7	24
India	48	15	66	30	--	--	--	--
Ireland	825	467	1,070	421	18	13 r	5	5
Italy	--	--	250	73	--	--	--	--
Japan	3,560	1,340	5,830	1,330	--	--	87	77
Korea, Republic of	373	83	1,220	530	--	--	7	9
Mexico	157	56	72	31	20	44 r	38	90
United Kingdom	115	73	323	192	7	12 r	7	3
Other	1,830	437	1,020	803	4	7 r	29	53
Total	9,720	3,860	17,800	7,810	165	381	417	922
Grand total	75,200	34,900	128,000	58,800	1,680	2,660	2,750	2,700

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States codes 7105.10.0025 for synthetic and 7105.10.0010 for natural.

[3] Customs value.

Source: U.S. Census Bureau.

TABLE 5

NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE [1, 2, 3]

(Thousand carats)

Country and type[4]	2006	2007	2008	2009	2010
Gemstones:					
Angola	8,258	8,732	8,016	12,445	12,500 [e]
Armenia	184	123	101	50	50 [e]
Australia	7,305	231	273	220 [r, e]	100 [e]
Botswana[e]	24,000	25,000	25,000	24,000	25,000
Brazil[e]	181	182	182	200 [r, 5]	200
Canada	13,278	17,144	14,803	10,946	11,773
Central African Republic[e]	340	370	302 [r, 5]	249 [r, 5]	250
China[e]	100	100	100	100	100
Congo (Kinshasa)	5,800	5,700	4,200	3,700 [r]	5,500
Côte d'Ivoire[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Ghana	768	671	478	301 [r]	300 [e]
Guinea	355	815	2,500	557 [r]	550
Guyana	341	269	169	144	144 [e]
Lesotho	231	454	450 [e]	450 [e]	460
Namibia	2,400	2,266	2,435	1,192 [r]	1,200 [e]
Russia[e]	23,400	23,300	21,925 [5]	17,791 [5]	17,800
Sierra Leone	362	362	223	241 [r]	240 [e]
South Africa[e]	6,100	6,100	5,200	2,500 [r]	3,500
Tanzania[e]	230	239	202	155 [r]	77
Venezuela[e]	45	45	45	45	45
Zimbabwe[e]	160	100	100	100	50
Other[6]	70	75 [r]	121 [r]	79 [r]	70
Total	93,900 [r]	92,300 [r]	86,800 [r]	75,500 [r]	79,900
Industrial:					
Angola[e]	918	970	900	1,383 [r, 5]	1,300
Australia	21,915	18,960	15,397	10,700	9,900
Botswana[e]	8,000	8,000	8,000	7,000	7,000
Brazil[e]	600	600	600	600	600
Central African Republic[e]	85	93	74 [5]	62 [r, 5]	60
China[e]	965	970	1,000	1,000	1,000
Congo (Kinshasa)	23,100	22,600	16,700	14,600 [r]	22,200
Côte d'Ivoire[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Ghana	192	168	120	75 [r]	75 [e]
Guinea	118	200	600	139 [r]	130
Russia[e]	15,000	15,000	15,000	15,000	15,000
Sierra Leone	241	241	149	160 [r]	160 [e]
South Africa[e]	9,100	9,100	7,700	3,600 [r]	5,400
Tanzania[e]	42	44	36 [r]	27	14
Venezuela[e]	70	70	70	70	70
Zimbabwe[e]	900	600	700	850 [r]	800
Other[7]	67	84 [r]	145 [r]	115 [r]	118
Total	81,300 [r]	77,700 [r]	67,200 [r]	55,400 [r]	63,800
Grand total	175,000 [r]	170,000 [r]	154,000 [r]	131,000 [r]	144,000

[e] Estimated. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 2, 2011.

[3] In addition to the countries listed, Nigeria and the Republic of Korea produce natural diamond and synthetic diamond, respectively, but information is inadequate to formulate reliable estimates of output levels.

TABLE 5

NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE [1, 2, 3]

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[4] Includes near-gem and cheap-gem qualities.

[5] Reported figure.

[6] Includes Cameroon, Congo (Brazzaville), Gabon (unspecified), India, Indonesia, Liberia, and Togo (unspecified).

[7] Includes Congo (Brazzaville), India, Indonesia, and Liberia.

TABLE 6

SYNTHETIC DIAMOND: ESTIMATED WORLD PRODUCTION, BY COUNTRY [1, 2, 3]

(Thousand carats)

Country	2006	2007	2008	2009	2010
Belarus	25,000	25,000	25,000	25,000	25,000
China	3,900,000	4,000,000	4,000,000	4,000,000	4,000,000
Czech Republic	5	5	5	5	5
France	3,000	3,000	3,000	3,000	3,000
Ireland	60,000	60,000	60,000	60,000	60,000
Japan	34,000	34,000	34,000	34,000	34,000
Russia	80,000	80,000	80,000	80,000	80,000
South Africa	60,000	60,000	60,000	60,000	60,000
Sweden	20,000	20,000	20,000	20,000	20,000
Ukraine	8,000	8,000	8,000	8,000	8,000
United States	128,000	130,000	131,000 [4]	91,000 [4]	93,000
Total	4,320,000	4,420,000	4,420,000	4,380,000	4,380,000

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 2, 2011.

[3] In addition to the countries listed, Germany and the Republic of Korea also produces significant amounts of synthetic diamond, but output is not officially reported, and available information is inadequate to formulate reliable estimates of output levels.

[4] Reported figure.

DIATOMITE

By Robert D. Crangle, Jr.

Domestic survey data and tables were prepared by Elsie D. Isaac, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Production of diatomite in the United States increased by 3% to 595,000 metric tons (t), with a corresponding value of $178 million free on board (f.o.b.) plant in 2010 compared with 575,000 t valued at $147 million f.o.b. plant in 2009 (table 1). The United States remained the world's leading producer and consumer of diatomite. Estimated world production was 1.82 million metric tons (Mt), a slight decrease from the previous year.

Diatomite used for filtration represented 67% of consumption, followed by its use as a cement additive (15%), an absorbent (11%), and as a filler (7%). Other diatomite applications, including abrasives, insecticides, and soil conditioner, accounted for the remainder (table 2). Major diatomite products were sold as various grades of calcined powders.

Encroachment into diatomite markets by natural and synthetic substitute material remained minimal, particularly for beverage filtration. Use as a biological filter for human blood plasma continued to increase.

Diatomite is a chalk-like, soft, friable, earthy, very fine-grained, siliceous sedimentary rock comprised of fossilized diatom remains. Diatomite often has a light color (white if pure, commonly buff to gray in-situ, and rarely black). It is extremely lightweight because of its low density and high porosity, and essentially chemically inert. Diatomaceous earth (often abbreviated as D.E.) is a common alternate name but is more appropriate for the unconsolidated or less lithified sediment. Diatomite is also known as kieselguhr (Germany), tripolite (after an occurrence near Tripoli, Libya), and moler (an impure Danish form). Alfred Nobel named his explosive invention "dynamite" following his discovery that nitroglycerin could be stabilized if first absorbed in diatomite (Nobel, 1868).

Diatomite deposits form from an accumulation of amorphous hydrous silica cell walls of dead diatoms in both oceanic and fresh waters. These microscopic single-cell aquatic plants (algae) contain an internal, elaborate siliceous skeleton consisting of two frustules (valves) that vary in size from less than 1 micrometer (µm) to more than 1 millimeter in diameter but are typically 10 to 200 µm in diameter. The frustules have a broad variety of delicate, lacy, perforated shapes, including cylinders, discs, feathers, ladders, needles, and spheres. Additional information on the environmental and physical properties of diatoms can be found in Dolley and Moyle (2003) and Moyle and Dolley (2003). The oldest occurrences of diatomite are thought to be of Cretaceous age, deposited about 66 million to 138 million years ago. Older diatomite occurrences may have been altered into other forms of silica, particularly chert, owing to diagenesis, burial, and exposure. Detailed information on the geology of diatomite can be found in Wallace (2003) and Moyle and Dolley (2003).

Production

Domestic production data for diatomite were developed by the U.S. Geological Survey (USGS) from a voluntary annual survey of U.S. diatomite-producing sites and company operations. The USGS canvass for 2009 covered 7 diatomite-producing companies with 10 mining areas and 9 processing facilities. All companies responded, accounting for 100% of the production listed in table 1. Some company data were not complete and were estimated on the basis of annual hours worked, as reported by the Mine Safety Health Administration. Data were rounded to no more than three significant figures. All percentages in this report were computed based on unrounded data.

In 2010, 595,000 t of diatomite were produced from 10 separate mining areas and 9 processing facilities in California, Nevada, Oregon, and Washington. Major producers were Celite Corp. (a subsidiary of Imerys USA, Inc.) with mines and facilities in California, Nevada, and Washington, and EP Minerals, LLC (a subsidiary of EaglePicher Corp.) with operations in Nevada and Oregon. California was the leading producing State, followed by Nevada. The combined output of these two States accounted for about 75% of U.S. production in 2010.

Because diatomite occurrences are at or near the earth's surface, recovery from most deposits is achieved through low-cost, open pit mining. Outside the United States, however, underground mining is fairly common owing to deposit location and topographic constraints. Explosives are generally not required for surficial or subsurface mining because of the soft, friable nature of the deposits. In Iceland, dredging is used to recover lake-bottom diatomaceous mud deposits.

Diatomite is often processed near the mine to reduce transportation costs associated with the crude ore, which can contain up to 65% water. Processing typically involves a series of crushing, drying, size-reduction, and calcining operations, using heated air for conveying and classifying within the plant. Fine-sized diatomite grains, especially from baghouses, are used most often for filler-grade products, while coarser particles are employed for filtration purposes. In the latter processing stages, calcining is performed in rotary kilns to effect chemical and physical changes.

Diatomite production costs for the United States average 10% for mining, 60% to 70% for processing, and 20% to 30% for packing and shipping. Energy costs compose a large and growing portion (25% to 30%) of diatomite production costs, both in the direct costs of mining and transportation, as well as within the energy-intensive calcining process. Diatomite used for cement production does not normally require calcining, and the reported unit value is considerably lower. For 2010, overall diatomite production was slightly higher than 2009, but well below the pre-economic downturn levels observed in 2006 [799 million metric tons (Mt)], 2007 (687 Mt), and 2008 (764 Mt) when annual production levels were as much as 25% higher. Diatomite's use as a concrete additive, in insulation, and as a filler decreased as a result of the decline of the construction sector since 2008.

Consumption

Apparent domestic consumption of diatomite was approximately 509,000 t in 2010, an increase of approximately 4% from 488,000 t in 2009. The total domestic and export quantity of filter-grade diatomite sold or used by U.S. producers was 400,000 t in 2010, an increase of 25% from 320,000 t in 2009, accounting for 67% of total diatomite sold or used. Diatomite remains the dominant filtration medium with estimates suggesting it represents 65% of the total filtration market (Moores, 2008). Diatomaceous earth used in cement manufacture accounted for 91,000 t, or 15%, of total diatomite production in 2010, a decrease of 33% from 136,000 t. Production of diatomite as an insulation component was not reported in 2010, following the production of 10,000 t in 2009.

For absorbents, 64,000 t of diatomite was reported, an increase of 14% from 56,000 t in 2009, accounting for 11% of total diatomite sold or used. Use of diatomite as a filler was 40,000 t in 2010, a decrease of 25% from the 53,000 t in 2009, which accounted for 7% of total diatomite sold or used.

In antiquity, diatomite was used by the Greeks as an abrasive and in the production of lightweight building bricks and blocks. In the late 1800s, diatomite became of industrial interest in Western Europe when pulverized diatomite was the preferred absorbent and stabilizer of nitroglycerine used to make dynamite. Maryland was the site of the first U.S. production of diatomite in 1884. By the late 1880s, very pure, large deposits near Lompoc, CA, became the focus of interest and have continued to dominate world markets (Dolley and Moyle, 2003). While diatomite is principally used as a filtration medium, other uses include as a silica additive in cement and various other compounds, a filler in a variety of products from paints to dry chemicals, an absorbent for industrial spills and pet litter, an insulation medium in sawn and molded shapes and loose granules, a mild abrasive in polishes, and an agent in the purification and extraction of DNA.

Commercial diatomite products provide fine-sized, irregular-shaped, porous noncaking particles that have a large surface area and high liquid-absorption capacity. They are relatively chemically inert, have a low refractive index, are mildly abrasive, have a low thermal conductivity with a reasonably high fusion point, can be slightly pozzolanic, are very high in silica, and can be produced and delivered at a cost consistent with customer applications. Sawn shapes, which continue to account for a significant part of world diatomite production, have long been used as lightweight building material, especially in China, and primarily for thermal insulation (especially the high-clay-content Danish moler). Both dried natural products and calcined products are used in building applications. The major use of diatomite continues to be as a filtration medium for beverages (especially beer and wine), sugar and sweetener liquors, oils and fats, petroleum and chemical processing (including reprocessing waste dry cleaning fluids), pharmaceuticals, and water (industrial process, potable, swimming pool, and waste). Another leading use is as an absorbent for industrial spills (oil and toxic liquids) and for pet litter.

Another important broad category of use is as a filler, often serving a dual purpose, such as an extender and flatting agent in paints and coatings; a bulking and anticaking agent in granular materials; and as a multieffect component in plastics (including preventing films from sticking). Other filler uses are as an extender and absorbent carrier for catalysts, nontoxic pesticides (as a desiccating agent), pharmaceuticals, and other chemicals. Other significant uses are as an insulation material in bulk (loose) and molded forms, and as a silica additive in various compounds, including mortar and portland cement, where its pozzolanic properties are utilized.

Commercial diatomite products are offered in a variety of grades. Principal grading factors are the size, shape, overall arrangement, and proportions of the various types of frustules (factors that affect filtration rate, product clarity, and absorption capacity). Other factors include silica content, impurity levels (especially iron), and the presence of clay, sand, and organics. Brightness, whiteness, and abrasive hardness are considered for specialized diatomite applications. Free-crystalline silica content, although normally low, is required to be identified, particularly for calcined products. Calcining removes organics, increases filtration rate, oxidizes iron, increases specific gravity, increases particle hardness, and can lighten color. Flux-calcining significantly affects the physical and chemical properties and makes a white product. Most filter grades are calcined.

Prices

The calculated weighted average unit value of diatomite sold or used by U.S. producers during 2010, using USGS survey data and estimates, was $299 per metric ton f.o.b. plant, an increase of about 17% compared with about $255 per ton in 2009 (table 3). The average values for filtration increased by 5% in 2010 to $394 per ton from $375 per ton reported in 2009. The value for diatomite used for absorbent purposes was unchanged at $41 per ton. The unit value for material used as fillers decreased slightly to $412 per ton in 2010. The average value for specialized or other uses in 2010 decreased by 64% to $705 per ton from $1,960 per ton in 2009. This decrease was derived from a specialty-grade form of diatomite, which is subject to large price fluctuations, and represented less than 1% of total U.S production in 2010.

Foreign Trade

Export and import data presented here from the U.S. Census Bureau may be of limited accuracy. This is a result of reporting inconsistencies from producers and a lack of detail caused by the inclusion of diatomite with other mineral commodities within several categories in the 2010 Harmonized Tariff Schedule of the United States (HTS) issued by the U.S. International Trade Commission. Exports of diatomite from the United States in 2010 were approximately 86,000 t, about 2,000 t less than in 2009 (table 4). Exports accounted for about 14% of total domestic production sold or used. The trade data were issued under heading 2512 of the HTS, described as applying to siliceous fossils, including kieselguhr, tripolite, diatomite, and similar siliceous earths of an apparent specific gravity of 1 or less. Industry sources, however, indicated that exports also included some flux-calcined material, which is included under code 3802.90.2000, where it is not differentiated from activated clays. Similarly, heat-insulating mixtures and sawn and molded unfired shapes of diatomite are collected under data classification code 6806.90.0090 and are not exclusively identified as diatomite. Lastly, fired, sawn, and molded shapes of diatomite are covered under heading 6901, which is not exclusively used for diatomite data.

According to the U.S. Census Bureau data, diatomite and diatomite products were exported to 89 countries in 2010, with 25 countries accounting for 85% of the total. The main export markets were Canada (18,300 t), Germany (10,400 t), Russia (3,940), Belgium (3,730 t), Japan (3,460 t), United Kingdom (2,680 t), Australia (2,480 t), South Africa (2,380 t), Austria (2,240 t), and Vietnam (2,240 t). These 10 countries accounted for 60% of the total reported exports. Based on available trade data from the U.S. International Trade Commission, the average unit value free alongside ship of exported diatomite was $517 per ton in 2010 compared with $467 per ton in 2009, an increase of 11% (table 4). Import data for diatomite show that 1,030 t came from 13 countries in 2010. Mexico was the leading source with 385 t (37%); followed by the Netherlands with 238 t (23%), Italy with 156 t (15%), Australia with 128 t (12%), and France with 57 t (6%). These five countries provided 93% of the imports to the United States in 2010.

World Review

Estimated world production of diatomite in 2010 was 1.82 Mt (table 5). World reserves are thought to be almost 1 billion metric tons (Gt), which is more than 500 times the current annual estimated world production rate of 1.82 Mt. About 250 Mt, or 25% of the estimated 1 Gt of world reserves, is in the United States (Crangle, 2010). The world's reputed largest producing district in terms of volume is near Lompoc, CA. A resource assessment of this location suggested these deposits could meet all of the world's current diatomite consumption for hundreds of years. Compiling data regarding reserve estimates can be challenging because some data are proprietary and not released by companies nor by countries. Huge deposits, on the order of at least 110 Mt of reserves, have been reported to occur in China (Lu, 1998, p. 53).

The four leading diatomite producers in 2010 were, in decreasing order of production, the United States, China, Denmark, and Japan. The United States continued to be the leading producer, consumer, and exporter of diatomite, and accounted for 33% of total world production, followed by China with 22%, Denmark with 12% (all moler products), and Japan with 6%. Smaller amounts of diatomite were mined in 25 additional countries.

Outlook

Despite challenging market conditions for many industrial commodities, domestic diatomite production and prices increased in 2010. The economic stability of the mineral commodity was largely owing to its use as a filtration medium, where its demand remains strong, particularly in the filtration of spirits as well as human blood plasma and other biotechnical applications. Likewise, the encroachment of more advanced filter applications, including carbon membranes, ceramics, and polymers, were not a concern in 2010. The high costs associated with these alternatives and a cultural preference toward the use of diatomite in the brewing and wine industries indicate a strong likelihood for the continued and widespread use of diatomite in filtration.

The associated issue of free-crystalline silica, particularly after diatomite is calcined, was expected to continue to be a concern, especially in the filler and absorbent markets. Although some diatomite deposits were reported to be low in free-crystalline silica, an effort to classify diatomite and related absorbent products as free of this material remains contentious, litigious, and, to date, unsuccessful. The use of uncalcined diatomite has replaced its calcined counterpart in some markets. Adequate supplies of diatomite, owing to the large domestic and world reserves, coupled with small or no changes in demand, will probably remain available for the foreseeable future.

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TABLE 1
DIATOMITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES[1]

(Thousand metric tons and thousand dollars)

	2009	2010
Domestic production, sales:		
Quantity	575	595
Value	147,000	178,000

[1] Data are rounded to no more than three significant digits.

TABLE 2
DIATOMITE SOLD OR USED, BY MAJOR USE[1]

(Percentage of U.S. production)

	2009	2010
Absorbents	10	11
Cement[2]	24	15
Fillers	9	7
Filtration	55	67
Insulation	2	--
Other[3]	(4)	(4)

-- Zero.

[1] Includes exports.

[2] As ingredient in portland cement.

[3] Includes abrasives, lightweight aggregates, and unspecified uses.

[4] Less than ½ unit.

TABLE 3
AVERAGE VALUE PER METRIC TON OF DIATOMITE, BY MAJOR USE[1]

	2009	2010
Absorbents	41	41
Cement[2]	7	9
Fillers	421	412
Filtration	375	394
Insulation	50	--
Other[3]	1,960	705
Weighted average	255	299

-- Zero.

[1] Rounded estimates.

[2] As ingredient in portland cement.

[3] Includes abrasives, lightweight aggregates, and unspecified uses.

TABLE 4
U.S. EXPORTS OF DIATOMITE[1, 2]

(Thousand metric tons and thousand dollars)

Year	Quantity	Value[3]
2009	88	41,100
2010	86	44,500

[1] Harmonized Tariff Schedule (HTS) heading 2512.00.0000, natural and straight-calcined grades, but in practice probably includes an undetermined quantity of flux-calcined product HTS heading 3806.90.2000.

[2] Data are rounded to no more than three significant digits.

[3] Free alongside ship value.

Source: U.S. Census Bureau.

TABLE 5

DIATOMITE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1,2]

(Thousand metric tons)

Country	2006	2007	2008	2009	2010
Algeria	2	2[3]	2	2	2
Argentina	39[3]	50[3]	37[3]	62[r,3]	50
Australia	20	20	20	20	20
Brazil, marketable	9[3]	6[3]	6[3]	6	6
Chile	19[3]	25[3]	25[3]	23[r,3]	25
China	420	420	440	440	400
Commonwealth of Independent States[4]	80	80	80	80	80
Costa Rica	3[3]	2[r,3]	1[r,3]	1[r]	1
Czech Republic	53	19	31	--	--
Denmark[5]	235	230	230	225	225
France	75	75	75	75	75
Germany	2	2	2	2	2
Iceland	28	28	28	26	25
Iran[6]	2	(7)	2[r]	2[r]	2
Italy	25	25	25	25	25
Japan	130	120	115	110	110
Kenya	(7)	(7)[3]	(7)[3]	(7)[3]	(7)
Korea, Republic of	3[3]	2[3]	3[3]	2[r]	3
Macedonia	5	5	5	5	5
Mexico	63[3]	63[3]	129[r,3]	81[r,3]	80[3]
Mozambique	1	1[3]	(7)[3]	(7)	(7)
Peru	35	22[3]	12[3]	10[3]	10
Poland	1	1	1	1	1
Portugal	(7)	(7)	(7)	(7)	(7)
Romania	2[3]	2	--	--	--
Spain[8]	52	50	50	50	50
Thailand	1[3]	1[3]	4[3]	4[r]	4
Turkey	45[3]	33[3]	63[r,3]	28[r,3]	30
United States[9]	799[3]	687[3]	764[3]	575[3]	595[3]
Total	2,150	1,970	2,150[r]	1,860[r]	1,820

[r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown. Purity and moisture content are generally not reported or estimated.

[2] Table includes data available through April 20, 2011.

[3] Reported figure.

[4] Information is inadequate for formulation of reliable estimates for individual countries.

[5] Data represent "extracted moler" (reported cubic meters times 1.5). Contains about 30% clay.

[6] Data are for Iranian years beginning March 21 of that stated.

[7] Less than ½ unit.

[8] Includes tripoli.

[9] Sold or used by producers.

EXPLOSIVES

By Lori E. Apodaca

In 2010, U.S. explosives consumption was 2.68 million metric tons (Mt), about an 18% increase from that of 2009; sales of explosives were reported in all States except Delaware. Coal mining, with about 71% of total consumption, continued to be the dominant use for explosives in the United States. Wyoming, West Virginia, and Kentucky, in descending order, led the Nation in coal production, accounting for 63% of the total. These States were also the leading explosives-consuming States, accounting for 46% of total U.S. explosives sales.

Legislation and Government Programs

Effective February 3, the Occupational Safety and Health Administration (OSHA) terminated the rulemaking that had been proposed in 2007 to amend its Explosives and Blasting Agents Standard (CFR 1910.109). In 2007, The Institute of Makers of Explosives (IME) and the Sporting Arms and Ammunition Manufacturers' Institute petitioned OSHA to revise the standard. However, the rule had been on hold since 2007 because additional clarification was needed as to the intent of the rulemaking. OSHA concluded that other Federal agencies already regulated explosives hazards in many situations; therefore, this proposal had limited scope and would not have amended many of the substantive requirements that were part of OSHA's existing explosives standard (Occupational Safety and Health Administration, 2010).

Production

Sales of ammonium-nitrate-based explosives (blasting agents and oxidizers) were 2.65 Mt, which was about an 18% increase from those in 2009, and accounted for about 99% of U.S. industrial explosives sales. Sales of permissibles (explosives approved for use in gassy and dusty environments) were about 39% lower than those in 2009, and sales of other high explosives decreased by about 5% (table 1).

Companies contributing data to this report, that are members of the IME, are as follows:

Accurate Energetic Systems, LLC
Austin Powder Co.
Baker Atlas (a division of Baker Hughes Inc.)
Davey Bickford USA, Inc.
Douglas Explosives, Inc.
Dyno Nobel Inc.
GEODynamics, Inc.
Jet Research Center (a division of Halliburton Co.)
Maine Drilling & Blasting Inc.
Maxam North America, Inc.
Nelson Brothers Inc.
Orica USA Inc.
Owen Oil Tools LP (a division of Core Laboratories N.V.)
Senex Explosives Inc.
Titan Specialties Ltd.
Vet's Explosives Inc.
Viking Explosives and Supply Inc.
W.A. Murphy, Inc.

El Dorado Chemical Co. (a subsidiary of LSB Industries Inc.) signed a 5-year agreement with Orica International Pte Ltd. (Orica) to supply Orica with 230,000 metric tons per year (t/yr) of industrial-grade ammonium nitrate. The new agreement replaces the previous agreement to supply 190,000 t/yr of ammonium nitrate to Orica (Green Markets, 2010b).

Apache Nitrogen Products Inc. was investing $5.5 million to upgrade its Arizona ammonium nitrate prill plant. They were replacing the dry end of the prill ammonium nitrate process in order to reduce moisture problems. Sixty percent of the liquid ammonium nitrate produced onsite was used to produce low-density ammonium nitrate prill for use in the mining industry. Ammonium nitrate production capacity was 180,000 t/yr (Green Markets, 2010a).

Consumption

The principal application for explosives in the United States was coal mining, accounting for about 71% of the total explosives sales for consumption (table 2). In 2010, U.S. coal production increased slightly to 985 million metric tons, according to preliminary data from the U.S. Energy Information Administration (EIA) (Watson and others, 2011, p. 1). Coal production decreased in the Appalachian region by 2.1%, compared with production in 2009. In the Interior (midwest) and Western regions of the United States, coal production increased by 7.4% and 1.1%, respectively (Watson and others, 2011, p. 5). Three States (Wyoming, West Virginia, and Kentucky, in descending order) led the Nation in coal production, accounting for 63% of the total. These States were also the leading explosives-consuming States.

Construction and quarrying and nonmetal mining each accounted for 9% of total explosives sales; metal mining, 8%; and miscellaneous uses, 3%. Wyoming, West Virginia, Kentucky, Indiana, Nevada, Virginia, and Pennsylvania were, in descending order, the leading explosives consuming States (greater than 100,000 metric tons sold), with a combined total of 65% of U.S. sales (table 3).

The dollar value of new construction (residential and nonresidential) put in place in 2010 decreased by 11% compared with that in 2009 (U.S. Census Bureau, 2011). Based on monthly data, the seasonally adjusted industry growth rate from 2009 to 2010 for metal mining was 8.9%, and the growth rate for quarrying and nonmetallic mineral mining was 2.5% (Federal Reserve Board, 2011).

Classification of Industrial Explosives and Blasting Agents.—Apparent consumption of commercial explosives used for industrial purposes is defined in this report as sales as reported to the IME. Commercial explosives imported for industrial uses were also included in sales. The principal distinction between high explosives and blasting agents is their sensitivity to initiation. High explosives are cap sensitive, whereas blasting agents are not. Black powder sales were minor and were last reported in 1971. The production classifications used in this report are those adopted by the IME.

High Explosives.—*Permissibles.*—The Mine Safety and Health Administration (MSHA) approved grades by brand name as originally established by the National Institute for Occupational Safety and Health (NIOSH) testing.

Other High Explosives.—These include all high explosives except permissibles.

Blasting Agents and Oxidizers.—These include ammonium nitrate-fuel oil (ANFO) mixtures, regardless of density; slurries, water gels, or emulsions; ANFO blends containing slurries, water gels, or emulsions; and ammonium nitrate in prilled, grained, or liquor (water solution) form. Bulk and packaged forms of these materials are included in this category. In 2010, about 96% of the total blasting agents and oxidizers sales was in bulk form.

World Review

Australia.—Incitec Pivot Ltd. announced that it would restart construction of the AUD935 million Moranbah ammonium nitrate plant in Central Queensland in May. The plant was delayed for almost a year as the demand for explosive products had fallen. The Moranbah project, a 330,000-t/yr fully integrated ammonium nitrate complex, was expected to begin production in 2012 (Incitec Pivot Ltd., 2010).

Incitec Pivot revived its plans for an explosives-grade ammonium nitrate plant at the King Bay/Hearson Cove Industrial Estate on the Burrup Peninsula in Western Australia. The plant was expected to produce 350,000 t/yr of ammonium nitrate. Construction was expected to start in early 2012, with operations beginning in 2014 (Fertilizer Week, 2010b).

In August, Burrup Nitrates Pty Ltd. [a joint venture between Burrup Holdings Ltd. (BHL) and Yara International ASA] received approval to build a 350,000-t/yr technical-grade ammonium nitrate plant on the Burrup Peninsula adjacent to BHL's 760,000-t/yr ammonia plant. Construction was planned to begin in late 2010 and be completed by 2013 (Burrup Nitrates Pty Ltd., 2010; Fertilizer Week, 2010a).

Egypt.—The Egypt Hydrocarbon Corp. secured financing to build a large-scale ammonium nitrate and nitric acid complex in Suez at a cost of $298 million. KBR Inc. conducted feasibility and front-end engineering design studies. Uhde GmbH was awarded the engineering, procurement, and construction contract, and technology licenses for the 350,000-t/yr low-density ammonium nitrate and 300,000-t/yr nitric acid plants. The complex was expected to be completed by 2013 (Nitrogen + Syngas, 2011).

Indonesia.—PT Multi Nitrotama Kimia awarded CFI Holding Pte. Ltd. [the complete engineering package] including procurement management for its new ammonium nitrate complex in Cikampek. The complex would include a 300-metric-ton-per-day low-density ammonium nitrate plant and a low-density ammonium nitrate bagging unit. The plant was expected to be operational by 2011 (Fertilizer Week, 2010c).

South Africa.—Omnia Holdings Ltd. planned to build a $178.6 million ammonium nitrate and nitric acid complex at Sasolburg to meet the fast-growing demand in the local explosives and fertilizer markets. The new ammonium nitrate plant would have a production capacity of 330,000 t/yr, with output split between explosive- and fertilizer-grade ammonium nitrate. Uhde was contracted to provide plant technology and licenses, engineering design, and critical component supplies. The plant was expected to be completed by 2012 (Nitrogen + Syngas, 2010).

Outlook

According to the EIA, U.S. coal production in 2011 was expected to remain the same as that in 2010. In 2012, production was projected to increase by about 2.9% compared with that in 2011 to meet continued growth in coal consumption (U.S. Energy Information Administration, 2011, p. 8). Based on the coal production projections, explosives consumption was expected to remain about the same in 2011 as in 2010 and increase slightly in 2012.

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TABLE 1
SALIENT STATISTICS OF INDUSTRIAL EXPLOSIVES AND BLASTING AGENTS SOLD FOR CONSUMPTION IN THE UNITED STATES[1]

(Metric tons)

Class	2009	2010
Permissibles	1,610	990
Other high explosives	23,700	22,600
Blasting agents and oxidizers	2,240,000	2,650,000
Total	2,270,000	2,680,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: Institute of Makers of Explosives.

TABLE 2
ESTIMATED INDUSTRIAL EXPLOSIVES AND BLASTING AGENTS SOLD FOR CONSUMPTION IN THE UNITED STATES, BY CLASS AND USE[1, 2]

(Thousand metric tons)

Class	Coal mining	Quarrying and nonmetal mining	Metal mining	Construction work	All other purposes	Total
2009:						
Permissibles	2	(3)	(3)	(3)	--	2
Other high explosives	3	8	1	10	1	24
Blasting agents and oxidizers	1,580	201	175	225	56	2,240
Total	1,590	209	176	235	57	2,270
2010:						
Permissibles	1	(3)	(3)	(3)	--	1
Other high explosives	3	8	1	10	1	23
Blasting agents and oxidizers	1,880	244	225	236	66	2,650
Total	1,890	252	226	246	67	2,680

-- Zero.

[1] Distribution of industrial explosives and blasting agents by consuming industry estimated from indices of industrial production and economies as reported by the U.S. Department of Energy, the Federal Reserve Board, the U.S. Department of Transportation, and the U.S. Census Bureau.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Less than ½ unit.

TABLE 3

INDUSTRIAL EXPLOSIVES AND BLASTING AGENTS SOLD FOR CONSUMPTION IN THE UNITED STATES, BY STATE AND CLASS[1]

(Metric tons)

	2009				2010			
	Fixed high explosives				Fixed high explosives			
State	Permissibles	Other high explosives	Blasting agents and oxidizers	Total	Permissibles	Other high explosives	Blasting agents and oxidizers	Total
Alabama	14	257	95,900	96,200	37	191	91,800	92,000
Alaska	--	528	16,020	16,500	--	724	13,300	14,100
Arizona	39	119	25,500	25,700	15	273	39,200	39,500
Arkansas	--	123	15,800	15,900	--	100	19,600	19,800
California	15	539	20,500	21,100	--	352	23,400	23,700
Colorado	18	659	23,400	24,100	14	406	62,500	62,900
Connecticut	24	274	6,460	6,760	--	147	3,560	3,710
Delaware	--	--	--	--	--	--	--	--
Florida	--	93	28,300	28,400	--	77	13,300	13,300
Georgia	--	254	23,800	24,100	--	429	18,200	18,600
Hawaii	--	0	680	680	--	--	478	478
Idaho	--	151	9,510	9,660	1	58	11,600	11,600
Illinois	--	324	32,400	32,700	7	370	41,100	41,400
Indiana	70	980	189,000	190,000	--	1,410	159,000	160,000
Iowa	111	422	14,200	14,700	6	609	19,600	20,200
Kansas	--	119	6,640	6,760	--	82	11,600	11,700
Kentucky	206	1,330	292,000	293,000	182	1,400	281,000	283,000
Louisiana	--	571	4,010	4,580	--	238	2,670	2,910
Maine	--	183	3,620	3,800	--	190	2,890	3,080
Maryland[2]	--	272	9,750	10,000	11	463	14,800	15,200
Massachusetts	79	119	4,790	4,990	--	103	4,280	4,390
Michigan	--	125	23,700	23,800	--	92	25,400	25,400
Minnesota	--	56	16,600	16,700	--	103	83,900	84,000
Mississippi	--	18	5	22	--	39	(3)	40
Missouri	333	2,040	53,400	55,700	3	1,430	61,300	62,700
Montana	--	2,010	55,200	57,200	--	1,570	54,200	55,800
Nebraska	--	74	1,780	1,860	--	88	2,330	2,420
Nevada	29	1,220	21,600	22,800	327	1,060	115,000	116,000
New Hampshire	--	756	13,400	14,100	--	129	3,150	3,280
New Jersey	--	138	1,890	2,030	--	66	3,990	4,060
New Mexico	1	330	22,400	22,700	--	130	24,200	24,300
New York	8	734	5,640	6,380	(3)	555	13,400	13,900
North Carolina	--	575	20,400	21,000	--	313	17,800	18,100
North Dakota	--	11	2,650	2,660	--	10	2,610	2,620
Ohio	--	362	41,900	42,300	(3)	364	49,000	49,400
Oklahoma	--	140	19,600	19,700	--	747	20,800	21,600
Oregon	--	111	4,700	4,810	5	178	5,320	5,510
Pennsylvania	36	1,390	90,400	91,800	36	1,290	99,300	101,000
Rhode Island	--	25	914	939	--	31	1,360	1,390
South Carolina	--	205	4,970	5,170	--	76	5,420	5,500
South Dakota	--	54	4,380	4,430	--	23	7,160	7,180
Tennessee	--	1,420	28,000	29,400	--	2,440	28,300	30,800
Texas	18	699	62,700	63,500	--	994	33,900	34,900
Utah	43	219	64,100	64,400	37	302	62,800	63,100
Vermont	4	196	1,480	1,680	4	67	1,760	1,830
Virginia	299	1,560	114,000	116,000	119	817	113,000	114,000
Washington	53	670	7,950	8,670	43	630	18,500	19,200
West Virginia	154	758	348,000	349,000	138	806	334,000	335,000
Wisconsin	30	231	7,620	7,880	5	329	9,810	10,100

See footnotes at end of table.

TABLE 3—Continued

INDUSTRIAL EXPLOSIVES AND BLASTING AGENTS SOLD FOR CONSUMPTION IN THE UNITED STATES, BY STATE AND CLASS[1]

(Metric tons)

	2009				2010			
	Fixed high explosives				Fixed high explosives			
State	Permissibles	Other high explosives	Blasting agents and oxidizers	Total	Permissibles	Other high explosives	Blasting agents and oxidizers	Total
Wyoming	29	240	377,000	378,000	(3)	314	623,000	623,000
Total	1,610	23,700	2,240,000	2,270,000	990	22,600	2,650,000	2,680,000

– Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes the District of Columbia.

[3] Less than ½ unit.

Source: Institute of Makers of Explosives.

FELDSPAR AND NEPHELINE SYENITE

By Arnold O. Tanner

Domestic survey data and tables were prepared by Raymond I. Eldridge, III, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, feldspar production in the United States was estimated at nearly 550,000 metric tons (t) valued at $33.5 million, down from $35.6 million in 2009, based upon a combination of reported and estimated U.S. Geological Survey (USGS) data. Exports of feldspar in 2010 more than doubled to 16,800 t valued at $2.78 million, and imports of feldspar decreased by 3% to 2,050 t valued at $503,000. Imports of nepheline syenite (predominantly from Canada) increased by 20% to 368,000 t valued at slightly more than $52 million. World production of feldspar was estimated to be nearly 21 million metric tons (Mt) (tables 1, 7).

Apparent consumption of feldspar and imported nepheline syenite combined was slightly more than 1 Mt, primarily for use in the glass and ceramics industries and also as fillers in various products such as paints and coatings. Data on feldspar include silica producers that produce feldspar-quartz mixtures and one U.S. producer of aplite, a rock in which quartz and feldspar are the dominant minerals. Because domestic nepheline syenite production was consumed for use as roofing granules and in other construction applications (excluding ceramics, glass, and filler applications) the data were not included in this chapter. Trade data in this report are from the U.S. Census Bureau.

Feldspar

Production.—Feldspar was mined in seven States. These were, in descending order of estimated output, North Carolina, Virginia, California, Idaho, Georgia, Oklahoma, and South Dakota. North Carolina accounted for more than 40% of the total. Data on domestic production and sales and use of feldspar in this report are based upon data collected by the USGS by means of a voluntary survey. Nine companies mined feldspar and operated 12 beneficiation facilities—4 in North Carolina, 3 in California, and 1 in each of the 5 remaining States (table 3). Of these beneficiation facilities, eight responded to the canvass, representing about 70% of the 2010 production tonnages listed in tables 1 and 2, comparable with that of 2009. Production for the remaining operations was estimated from prior-year output levels.

Consumption.—Feldspar is used in the manufacture of glass and ceramics, and as a filler and extender in paint, plastics, and rubber. Of the domestic feldspar sold or used, an estimated two-thirds by tonnage went into the manufacture of glass, including glass containers, flat glass, glass fiber for home insulation, and specialty glass. In glassmaking, feldspar fluxes the system—lowering the melting temperature and helping promote the mixing of the melt components. The alumina from feldspar increases viscosity, inhibits devitrification, and acts as a stabilizer to improve product hardness, durability, and resistance to chemical corrosion. In ceramics, the alkalis (calcium, potassium, and sodium ions) in feldspar act as a flux, working with soda ash to lower the melting temperature of a mixture, as in glassmaking. Feldspar melts at an early stage in the firing process, forming a glassy phase or matrix in which the alkalis help to lower the melting temperature and soften the small crystalline and glassy components of the system and promote an increased fusing of the same (Roskill Information Services Ltd., 2008, p. 200). Pottery (including electrical insulators, sanitaryware, tableware, and tile) and other uses, such as fillers, accounted for the remainder of the feldspar consumed (table 4). The value of total feldspar sold or used listed in table 4 is higher than the feldspar production value listed in tables 1 and 2 because table 4 values represent the final marketed feldspar products.

The glass container industry in North America was moderately stable with regard to sales, although some container types, such as baby food, fruit juices, mineral water, and wine, and a recent trend to import less expensive containers from China, provided increasing competition for glass, and thus with its traditional raw materials. Cullet, especially from post-consumer "bottle-to-bottle" recycling programs, also competed with these raw materials. In late 2010, the North American glass container industry, with the goal of 50% recycled content by 2013, released its first comprehensive life cycle assessment (LCA) of glass used in glass packaging. The LCA enumerated several benefits achieved from increasing the amount of cullet in glass container production, including decreased primary energy costs, reduced greenhouse gas emissions, and extended life of glass manufacturing furnaces. Cullet use also decreased the demand for raw materials, including feldspar (Cattaneo, 2011).

The construction industry was a major consumer of products in which feldspar was one of the primary raw materials. In the United States, construction starts for new privately owned housing rose to 587,000 units in 2010, up from 554,000 units in 2009, although still notably lower than the 906,000 units started in 2008. Conversely, housing completions decreased to 650,000 units in 2010 from 790,000 units in 2009 and from 1.1 billion units in 2008 (U.S. Census Bureau, 2011a, b). Shipments of domestic tile increased to 60 million square meters (Mm^2), up nearly 14% in 2010 from that of 2009, the highest since 2005 when 61 Mm^2 were shipped (Whitmire, 2011).

World Review.—Feldspar was produced in more than 50 countries, with significant and potentially economic deposits of feldspar occurring in at least 70 countries. Turkey appears to have been the leading producing country with an estimated 5 Mt of feldspar in 2010, followed by Italy, with an estimated 4.7 Mt. China's production was estimated to be about 2.1 Mt. World production increased by an estimated 0.8 Mt to 20.6 Mt (table 7).

Recovery from the worldwide economic recession of 2008 and early 2009 for feldspar's two major consumer industries, glass and ceramics, continued in 2010. Ceramic tile production increased in Brazil, China, and India. Exports of ceramic tile from China, the world's leading exporter, continued to increase, although China's tile industry was substantially more dependent upon domestic consumption than exports. In Brazil and India, where ceramic industries depend on domestic consumption, significant increases in construction continued, resulting in increased domestic sales of ceramic tiles. Production of sanitaryware, to which feldspar is especially important in the firing process, increased significantly in China, Mexico, the Middle East, South America, and South East Asia, but decreased in Western Europe and the United States (Hao and Wilson, 2011).

European Union.—At the request of the European Ceramic Tile Manufacturers Federation (ECTMF) in 2010, the European Union (EU) launched an antidumping probe of imported ceramic tiles from China to determine whether low-valued Chinese imports had caused injury to the EU's ceramic tile industry. Depending on the results of the investigation to be completed within 15 months, antidumping duties could be assessed against Chinese imports in the EU for as long as 5 years, with individual EU governments determining whether to impose the duties (China International Publishing Group, 2010).

China.—As the world's leading producer and consumer of ceramic tiles, China increased production of sanitaryware by 11% in 2010 from that of 2009 to an annual output of 174 million pieces, of which 47% was produced in Henan Province. This represents nearly 40% of global production (Hao and Wilson, 2011). According to the China Ceramic Industry Association, exports of tiles and other construction-related ceramic products increased by 10% in 2010 from that of 2009; a trend that was expected to continue. In China's ceramics industry, feldspar prices increased 22% to 30% since 2008 owing to an increasing shortage of domestic raw material and increased energy and labor costs. Some prices rose to as much as $150 per metric ton, depending on the quality (Feytis, 2011a).

Greece.—Feldspar, typically sodium feldspar from pegmatites, is mined mostly in the northeastern part of the country. About 23,000 metric tons per year (t/yr) is produced for use in sanitaryware and glassware for domestic use and export. The Greek ceramic industries, particularly floor and wall tiles and sanitaryware, consume about 40,000 t/yr of feldspar, the largest portion of needed imports coming from the EU, especially from Turkey.

Mevior Co. SA (majority owned by Ankerpoort, a subsidiary of the Sibelco Group) mined pegmatites rich in sodium feldspar in the area of Karteres Thessaloniki. About one-half of Mevoir's production supplied domestic industries and the remainder was exported to the Czech Republic, Germany, and Italy. Filceram Johnson Co. SA mined feldspar in Platanochori Chalkidiki and typically consumed 30,000 t/yr of coarse-grained (0–6 millimeters) material for floor and wall tiles. The company suspended operations at yearend, likely for financial reasons (Tsirambides and Filippidis, 2012).

Italy.—Ranked as the world's second leading feldspar producer in 2010 with an estimated 4.7 Mt of production; most of Italy's output was used in the country's ceramics industry. Italy exported about 195,000 t of feldspar and imported nearly 2 Mt, more than 1.8 Mt of which was from Turkey (United Nations Statistics Division, undated a). Ceramic tile production, the Italian ceramic industry's leading sector, increased by 5% in volume and sales increased slightly in 2010 compared with those of 2009 (Ceramics of Italy, 2011). According to the Association of Italian Manufacturers of Machinery and Equipment for Ceramics, the sector exported more than 75% of its production, benefitting especially from growth in Asia, the Middle East, and South America (Feytis, 2011b).

Norway.—Sibelco Nordic (formerly North Cape Minerals AS) announced plans to close its pegmatite mine in Glamsland in 2011, a principal source of feldspar for the company's Lillesand feldspar/quartz plant. The closure was prompted by expensive processing costs and falling demand for feldspar in traditional cathode-ray tube television sets since the development of flat panel (liquid crystal display and plasma) televisions. The Lillisand plant was to continue feldspar production at the Fossbekk branch of the plant (Feytis and others, 2010).

Turkey.—Turkey, the world's leading feldspar producer in 2010, produced an estimated 5 Mt, of which about 3.7 Mt was exported; about two-thirds of the exports went to Italy and Spain (United Nations Statistics Division, undated a). Feldspar was mined in the southeast part of the country and exported to major ceramic manufacturing countries throughout Europe.

Nepheline Syenite

Production.—No nepheline syenite was produced in the United States for ceramic, glass, or filler use. Nepheline syenite with high iron content, however, was produced in Arkansas for use in roofing granules, road materials, asphalt and concrete aggregate, and related products.

Consumption.—In glass and ceramics manufacture, nepheline syenite, like feldspar, provides alkalis that act as a flux. In glass, nepheline syenite also supplies alumina, imparting the same benefits as feldspar.

World Review.—Nepheline syenite is produced in Brazil, Canada, China, Norway, Russia, and Turkey for feldspathic uses.

Canada.—Canada's sole nepheline syenite producer, Unimin Canada, Ltd., operated two plants at its Blue Mountain and Nephton, Ontario, deposits, about 175 kilometers northeast of Toronto. Production of marketable nepheline syenite was estimated to be about 580,000 t in 2010 (Natural Resources Canada, 2012). Detailed end-use data have not been available in recent years, but historically, the material had been consumed in glass, ceramics, filler, and abrasives markets. Total Canadian nepheline syenite exports were about 454,000 t in 2010, most of which went to the United States, 368,000 t; Italy, 42,000 t; and Spain, 21,000 t (United Nations Statistics Division, undated b).

China.—Hong Kong-based Fineton Industrial Minerals Ltd. produced about 50,000 t of nepheline syenite in 2010 at its plant in Anyang, Henan Province, to supply the ceramics, glass, and paint filler markets in China and other Asian markets. Previously, the company mostly exported to ceramic industries in Italy and Spain, but a decline in demand in those countries and increased freight rates resulted in lower exports to Europe. Fineton announced construction of a new 50,000-t/yr nepheline syenite plant in southern China to be completed in mid-2011 at its deposit in northern Quangdong Province (Industrial Minerals, 2010).

Norway.—Sibelco Nordic produces nepheline syenite during the summer and autumn from an open pit on the Arctic Island of Stjernoy. Processing of the ore, including crushing, drying, milling, sieving, magnetic separation, and air classification was performed on Stjernoy to produce different product sizes for the glass, ceramic, and paint industries. Data for 2010 were unavailable but output for 2009 was estimated to be 350,000 t. In 2010, total nepheline syenite exports from Norway were about 330,000 t, with Poland receiving about 79,000 t; the Netherlands, 77,000 t; Germany, 54,000 t; the United Kingdom, 41,000 t; Spain, 22,000 t; France, 15,000 t; and Portugal, 10,000 t; and the remainder to several other countries (United Nations Statistics Division, undated b).

Outlook

Producers of feldspar and nepheline syenite faced continuing challenges in 2011 and into the future related to excess supply and increased production costs that include motor fuels, natural gas and electric power, processing chemicals, and regulatory compliance. Higher transportation charges for shipping feldspathic products by rail and truck in 2012 likely will continue to increase delivered raw material costs to industrial consumers.

According to the Freedonia Group, U.S. glass food container demand is expected to rise modestly during the next several years, increasing feldspar consumption by glass container manufacturers. The use of glass containers in the United States may increase in the future as a result of consumer demand and Federal Government and State government initiatives for environmentally friendly and recyclable food and beverage packaging. However, increases in glass container recycling could reduce the need for raw materials to manufacture these containers.

The decreased use of flat glass during the past several years because of declines in the automobile and construction industries moderated in 2010, especially with an expansion of automobile production. Manufacturing of light vehicles in North America increased by 39% in 2010 compared with that of 2009, and in the United States, increased by 35% to 7.58 million units in 2010 from 5.61 million units in 2009. In the long-term, growth is expected (IHS Automotive Inc., 2011). When economic conditions improve, new residential construction and commercial and residential remodeling is expected to increase in 2011 and 2012, creating increased demand for glass and ceramics and thus feldspar.

Globally, ceramics industry growth significantly slowed during the 2008–09 recession, and with it, the use of feldspar. It is anticipated that the ceramic industry will rebound in the next few years. The main centers of ceramic production are China, India, Italy, Latin America, and Southeast Asia. Although consuming much of its own output, China is likely to continue as an important exporter of ceramic tile. Owing to continued recovery in the construction sector, increased demand for feldspar and associated raw materials is likely to follow. Innovative ideas and products in ceramics, such as thinner and stronger ceramic sheets that can be laid over existing tiled floors without the need for removal, and porcelain tiles that offer superior physical and chemical characteristics, are likely to help strengthen that sector. The main growth in feldspar demand is expected to be in Southeast Asia, China, Eastern Europe, India, and South America, potentially representing an average annual growth rate of about 5% (Roskill Information Services Ltd., 2008; Feytis, 2010).

Fiberglass consumption in the United States is forecast to increase as residential and commercial construction and resultant construction materials consumption increases by as much as 3% per year by 2013. This growth will be driven by efforts to reduce costs and broaden markets, with best growth prospects anticipated for glass wool fiber (O'Driscoll, 2009).

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TABLE 1

SALIENT FELDSPAR AND NEPHELINE SYENITE STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Produced, feldspar:						
Quantity[e, 2, 3]	thousand metric tons	760	730	650	550	550
Value[e, 2]	thousands	$44,600	$43,800	$40,000	$35,600	$33,500
Exports, feldspar:[4]						
Quantity	metric tons	10,400	9,980	14,600	7,520	16,800
Value[5]	thousands	$1,930	$1,950	$2,390	$1,150	$2,280
Imports for consumption[4]						
Feldspar:						
Quantity	metric tons	5,180	3,570	2,030	2,120	2,050
Value[6]	thousands	$549	$642	$646	$646	$503
Nepheline syenite:						
Quantity	metric tons	426,000	391,000	321,000	308,000	368,000
Value[6]	thousands	$36,000	$38,900	$35,000	$36,800	$52,400
Consumption, apparent[e, 7]	thousand metric tons	1,180	1,120	957	856	899
World, production[8]	do.	20,600 [r]	21,500	22,700 [r]	19,600 [r]	20,500 [e]

[e]Estimated. [r]Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits.

[2] Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-quartz mixtures, and aplite; may differ from sales in table 4.

[3] Rounded to two significant digits.

[4] Source: U.S. Census Bureau.

[5] Free alongside ship (f.a.s.) value.

[6] Customs value.

[7] Production plus imports minus exports. Includes feldspar and nepheline syenite.

[8] Feldspar only.

TABLE 2

ESTIMATED FELDSPAR PRODUCTION IN THE UNITED STATES[1]

(Thousand metric tons and thousand dollars)

	Flotation concentrate		Other[2]		Total	
Year	Quantity	Value	Quantity	Value	Quantity	Value
2009	210	13,600	340	22,000	550	35,600
2010	170	11,900	380	21,600	550	33,500

[1] Quantity data are rounded to two significant digits, and value data are rounded to three significant digits; may not add to totals shown.

[2] Includes hand-cobbed feldspar, feldspar content of feldspar-quartz mixtures, and aplite; excludes nepheline syenite.

TABLE 3
U.S. PRODUCERS OF FELDSPAR IN 2010

Company	Location	Product
APAC-Arkansas, Inc.	Muskogee, OK	Feldspar-quartz mixture.
Feldspar Corp.,The	Monticello, GA	Potassium feldspar.
Do.	Spruce Pine, NC	Sodium-potassium feldspar.
Graniterock Co.	Felton, CA	Feldspar-quartz mixture.
Kings Mountain Minerals Inc.	Kings Mountain, NC	Do.
K-T Feldspar Corp.	Spruce Pine, NC	Sodium-potassium feldspar; feldspar-quartz mixture.
Pacer Corp.	Custer, SD	Potassium feldspar.
P.W. Gillibrand Co. Inc.	Simi Valley, CA	Feldspar-quartz mixture.
Unimin Corp.	Byron, CA	Do.
Do.	Emmett, ID	Do.
Do.	Spruce Pine, NC	Sodium-potassium feldspar.
U.S. Silica Co.	Montpelier, VA	Aplite.

Do. Ditto.

TABLE 4
ESTIMATED FELDSPAR SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1, 2]

(Thousand metric tons and thousand dollars)

Use	2009		2010	
	Quantity	Value	Quantity	Value
Glass[3]	360	23,200	330	111,000
Pottery and miscellaneous	200	14,400	220	13,100
Total	550	37,600 [4]	550	124,000 [4]

[1] Includes hand-cobbed feldspar, flotation-concentrate feldspar, feldspar in feldspar-quartz mixtures, and aplite.

[2] Quantity data are rounded to two significant digits, and value data are rounded to three significant digits; may not add to totals shown.

[3] Includes container glass, glass fiber, and other glass.

[4] Represents final marketable product; value is higher than that listed for production in tables 1 and 2.

TABLE 5
U.S. EXPORTS OF FELDSPAR, BY COUNTRY[1]

(Metric tons and dollars)

	2009		2010	
Country	Quantity	Value[2]	Quantity	Value[2]
Brazil	--	--	134	35,100
Canada	880	230,000	1,260	356,000
China	14	13,200	151	82,500
Colombia	2,160	522,000	1,100	354,000
Ecuador	17	2,700	1,330	221,000
Norway	3,520	220,000	10,200	855,000
Russia	--	--	2,130	226,000
Trinidad and Tobago	464	70,400	179	52,200
Other (27 countries)	459 r	92,000 r	302	94,900
Total	7,520	1,150,000	16,800	2,280,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship value.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF FELDSPAR, BY COUNTRY[1, 2]

(Metric tons and dollars)

	2009		2010	
Country	Quantity	Value[3]	Quantity	Value[3]
Australia	3	2,340	--	--
Germany	836	371,000	516	201,000
Mexico	1,240	252,000	1,530	302,000
United Kingdom	40	19,800	--	--
Total	2,120	646,000	2,050	503,000

-- Zero.

[1] Excludes nepheline syenite (mostly from Canada), which is listed in table 1.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Customs value.

Source: U.S. Census Bureau.

TABLE 7

FELDSPAR: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country and grade[3]	2006	2007	2008	2009	2010[e]
Argentina	170,728	291,562	220,234	213,671	215,000
Australia, includes nepheline syenite[e]	50,000	50,000	50,000	50,000	50,000
Brazil, processed, marketable	77,285	166,089 [r]	121,952 [r]	115,264 [r]	115,000 [p]
Bulgaria[e]	93,091 [4]	90,000	90,000	80,000 [r]	80,000
Chile	5,847	6,704	17,834	9,079	10,000
China[e]	1,950,000	2,000,000	2,000,000	2,000,000	2,100,000
Colombia[e]	86,000	91,000	86,000	85,000	85,000
Cuba[e]	5,500	5,600	4,300	4,700 [r]	4,700
Czech Republic	487,000	514,000	488,000	431,000	388,000
Ecuador[e]	67,844 [4]	14,308 [4]	14,000	10,000	10,000
Egypt	360,000 [e]	135,290	407,320	353,623	355,000
Ethiopia[e]	478	459	424	199 [r]	300
Finland	56,263	48,890 [r]	45,250 [r]	45,000 [r]	45,000
France, crude[e]	650,000	650,000	650,000	650,000	650,000
Germany	167,332	171,303	161,416	106,837 [r]	150,000
Greece[e]	95,000	95,000	62,000 [4]	28,617 [4]	30,000
Guatemala	17,176	30,234	45,854	5,762	10,000
India	466,422 [r]	486,472 [r]	385,436 [r]	390,000 [e]	400,000
Iran[e]	290,000	512,261 [4]	501,821 [4]	500,000	500,000
Italy[e]	4,019,495 [4]	4,200,000	4,727,000 [4]	4,700,000	4,700,000
Japan, includes aplite[e]	800,000	750,000	700,000	700,000	650,000
Jordan	11,054	9,800	2,950	--	--
Kenya[e]	25	30	30	30	30
Korea, Republic of	427,378	398,513	344,257	622,700	600,000
Macedonia	32,824	32,814	28,920	19,377	20,000
Malaysia	142,358	358,775	457,377	356,620	360,000
Mexico	459,209	438,696	445,519	347,510 [r]	398,849 [4]
Morocco[e]	20,000	20,000	20,000	20,000	20,000
Nigeria[e]	1,700	1,700	1,700	13,631 [4]	10,000
Norway[e]	65,000 [r]	65,000 [r]	62,000 [4]	48,000	48,000
Pakistan	15,085	13,236 [r]	12,000 [r]	10,000 [r]	11,000
Peru	6,010 [e]	15,450	13,333 [r]	5,006	3,589 [4]
Philippines	15,176	14,837	15,838	16,394	17,000
Poland, run of mine[5]	431,300	497,900	599,100	445,500 [r]	450,000
Portugal	257,570	168,606	157,359	320,000	315,000 [p]
Romania[e, 6]	33,000 [r]	45,000 [r]	25,000 [r]	14,000 [r]	15,000
Russia[e]	45,000	45,000	45,000	45,000	45,000
Saudia Arabia	42,300	73,000	550,000	500,000 [e]	500,000
Serbia[e]	3,500	3,500	3,500	3,500	3,500
Slovakia[e]	5,000	5,000	5,000	13,000 [4]	13,000
South Africa	75,400	90,185	105,815	101,394	95,434 [4]
Spain, includes pegmatite[e]	674,766 [4]	680,000 [4]	690,000	550,000	550,000
Sri Lanka	56,864	28,866 [r]	32,586 [r]	35,000 [r]	36,000
Sweden, salable, crude and ground[e]	42,000	42,000	42,000	42,000	42,000
Thailand	1,067,684	684,668	670,618	600,000 [e]	600,000
Turkey	5,771,892	6,548,796	6,767,500	4,212,547	5,000,000
United Kingdom, china stone[e]	2,000	2,000	1,000	1,000	1,000
United States[e, 6]	760,000	730,000	650,000	550,000	550,000
Uruguay[e]	2,470 [4]	2,500	2,500	2,500	2,500

See footnotes at end of table.

TABLE 7—Continued
FELDSPAR: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country and grade[3]	2006	2007	2008	2009	2010[e]
Uzbekistan[e]	4,300	4,300	4,300	4,300	4,300
Venezuela[e]	200,000 [4]	200,000	200,000	200,000	200,000
Total	20,600,000 [r]	21,500,000	22,700,000 [r]	19,600,000 [r]	20,500,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 10, 2011.

[3] In addition to the countries listed, Namibia, the United Arab Emirates, and Yemen may produce feldspar, but ouput is not officially reported; and available information is inadequate to make reliable estimates of output levels.

[4] Reported figure.

[5] The dedicated feldspar run of mine production acounts for only part of total feldspar production.

[6] Rounded to two significant digits to avoid disclosing company proprietary data.

FERROALLOYS

By Lisa A. Corathers, Joseph Gambogi, Peter H. Kuck, John F. Papp, Désirée E. Polyak, and Kim B. Shedd

Domestic survey data and tables and the world production table were prepared by Glenn J. Wallace, international data coordinator.

Ferroalloys are alloys of iron employed to add chemical elements into molten metal, usually during steelmaking. Ferroalloys impart distinctive qualities to steel and cast iron or serve important functions during production and are, therefore, closely associated with the iron and steel industry, the leading consumer of ferroalloys. The leading ferroalloy-producing countries in 2010 were, in decreasing order of production, China, South Africa, India, Russia, and Kazakhstan (table 7). These countries accounted for 82% of world ferroalloy production. World production of bulk ferroalloys—chromium, manganese, and silicon—was estimated to have been 34.1 million metric tons (Mt) in 2010, a 16% increase compared with the revised figure of 29.3 Mt for 2009 (table 7).

Eleven companies in the United States produced 8 ferroalloys at 12 plants (table 1). With the exception of ferrosilicon, production statistics for most ferroalloys were concealed to avoid disclosing company proprietary data (table 7). U.S. reported consumption of bulk ferroalloys in 2010 was approximately 0.9 Mt of manganese and silicon ferroalloys (table 3) and about 0.3 Mt of contained chromium in ferrochromium (table 4). Comparing reported consumption in 2010 with that of 2009, ferrochromium increased by 12%, ferromanganese (including silicomanganese) increased by 12%, and ferrosilicon decreased by 3%. The United States was a net importer of ferroalloys and ferroalloy metals in 2010. On a gross weight basis and compared with that in 2009, U.S. total ferroalloy and ferroalloy metal imports increased by 104% and exports increased by 28%, which resulted in a net import increase of 64% (table 6).

Boron, chromium, cobalt, copper, molybdenum, nickel, niobium (columbium), phosphorus, silicon, titanium, tungsten, vanadium, zirconium, and the rare-earth elements are some of the other alloying elements used for the characteristics they provide to steels and cast irons (Brown and Murphy, 1985, p. 265).

Ferrochromium

The leading world chromite ore-producing countries in 2010 were South Africa (more than 10 Mt), India (more than 3 Mt), and Kazakhstan (more than 3 Mt). More than 95% of chromite ore production was smelted in electric-arc furnaces to produce ferrochromium for the metallurgical industry. The leading world ferrochromium-producing countries were China (2 Mt), Kazakhstan (1.3 Mt), and South Africa (3.6 Mt). India produced in excess of 0.8 Mt of ferrochromium. Most of the 8.71 Mt of ferrochromium produced was consumed in the manufacture of stainless steel. The leading stainless steel producing areas of the world—Asia (primarily China, India, Japan, the Republic of Korea, and Taiwan), Europe (primarily Western Europe and Scandinavia including Belgium, Finland, France, Germany, Italy, Spain, Sweden, and the United Kingdom), and the Americas (primarily Brazil and the United States)—accounted for most of world stainless steel production. World stainless steel production exceeded 30 Mt in 2010.

In response to anticipated future increases in demand, new ferrochromium-producing plants were under construction or planned in Kazakhstan and South Africa. Four industry trends were evolving—ferrochromium was being increasingly produced using environmentally friendly, energy- and recovery-efficient, prereduction, closed-furnace processes; chromium was being recovered from ferrochromium slag; the ferrochromium and stainless steel production industries were consolidating ownership; and strategic alliances between those two industries were being developed.

After the financial crisis of 2008 and subsequent economic downturn, 2010 was a year of recovery with ferrochromium production marginally exceeding the prefinancial-crisis level and reaching an historic high.

Ferromanganese

Two manganese ferroalloys, ferromanganese and silicomanganese, are key ingredients for steelmaking. Manganese ferroalloys were produced domestically by two companies—Eramet Marietta Inc. (owned by France's Eramet Group) and Felman Production Inc. (owned by Ukraine's Privat Group) (table 1). In addition to domestic production in 2010, the United States had to import 623,000 metric tons (t) of ferromanganese and silicomanganese (gross weight). Of that amount, 75% was imported from South Africa (274,000 t), Georgia (79,200 t), Norway (73,300 t), and Ukraine (40,300 t). China was the leading world producer of manganese ferroalloys, with output about 145% greater than that of the next three major producers—India, South Africa, and Ukraine—combined (table 7).

Ferromolybdenum

Chile, China, and the United States accounted for about 79% of world production of molybdenite ore in 2010. Three other molybdenite ore-producing countries—Canada, Mexico, and Peru—supplied an additional 15% of world production. Molybdenite concentrates are roasted to form molybdic oxide, which can be converted into ferromolybdenum, molybdenum chemicals, or molybdenum metal. About 46% of the total reported molybdenum consumed in the United States (19,200 t) was in the form of molybdic oxides, and about 24% was consumed as ferromolybdenum. Although the United States was the second leading molybdenum-producing country in the world, it imported almost one-half of its ferromolybdenum requirements in 2010. The steel industry accounted for most of the ferromolybdenum consumed in the United States in 2010, principally in the production of stainless and full alloy steels (table 4).

Ferronickel

In the United States, the steel industry accounted for virtually all the ferronickel consumed in 2010, with more than 97% used in stainless, heat-resistant, and certain alloy steels. No ferronickel was produced in the United States in 2010.

In 2010, the major ferronickel-producing countries were Japan (348,000 t), Colombia (145,000 t), and New Caledonia (145,000 t). Together, these three countries accounted for about 57% of world production if China is excluded. Indonesia, Greece, Ukraine, Macedonia, and the Republic of Korea, in descending order of gross-weight output, accounted for an additional 30%—again excluding China. China was not included in these calculations because its industry produced large tonnages of nickel pig iron in addition to a spectrum of conventional ferronickel grades, for an estimated combined output of 900,000 t gross weight. The nickel content of individual Chinese products varied from about 1.6% to as much as 80%, depending upon customer end use.

The Brazilian nickel industry completed construction of two greenfield ferronickel complexes during the fourth quarter of 2010. In October, Vale S.A. began ramping up production at its new $2.84 billion Onça Puma complex in the Ourilandia do Norte District, Para State. The Onça and Puma Mines, which lie 16 kilometers (km) from one another, have a combined 82.7 Mt of saprolitic reserves averaging 1.73% nickel. Ores from the two open pits were blended in coal-fired rotary kilns and then charged into electric furnaces to produce ferronickel. Commercial production of molten alloy at the Onça Puma complex began in March 2011. The smelter was expected to become fully operational in late 2012 with a production capacity of 53,000 t/yr of nickel-in-ferronickel (Hatch Ltd., undated, p. 22; Vale S.A., 2011).

In December 2010, Anglo American plc started its Barro Alto smelter in Goias State to process saprolitic ore from the adjoining Barro Alto Mine. Some ore from the Barro Alto Mine was already being processed at Anglo's existing Codemin ferronickel plant, located 170 km away in Niquelandia. In 2010, the Codemin plant produced 8,500 t of nickel-in-ferronickel from Barro Alto and Codemin ores. The Codemin open pit had 7.7 Mt of proven and probable lateritic reserves averaging 1.28% nickel. The Barro Alto open pit had 47.5 Mt of proven and probable lateritic reserves grading 1.68% nickel. The Barro Alto smelter was comprised of two 185-meter-long rotary kilns for calcining the raw ore and two 83-megawatt (MW) electric-arc furnaces for final smelting. The first molten ferronickel at Barro Alto was poured in March 2011. The Barro Alto smelter was expected to be fully operational in late 2012 with a production capacity of 41,000 t/yr of nickel-in-ferronickel. Capital expenditures for the Barro Alto smelter totaled $1.9 billion (Anglo American plc, 2011a; b, 59–68).

Société Minière du Sud Pacifique and its joint-venture partner, Xstrata plc, continued development of the Koniambo laterite deposit in New Caledonia. Nickel was to be extracted from saprolite ore and converted to ferronickel using an improved version of the pyrometallurgical process employed at Xstrata's Falcondo smelting and refining complex in the Dominican Republic. The bulk of the $3.85 billion project's infrastructure was completed by the beginning of 2010. Erection of the smelter and 270 MW powerplant was essentially finished by January 2011, with commissioning scheduled for the second half of 2012. When fully operational in 2014, the Koniambo smelter would be capable of producing 60,000 t/yr of nickel in ferronickel shot. The shot was expected to average 35% nickel, 63% iron, and 0.9% cobalt (Usmar, 2011).

On December 31, 2009, Horsehead Holding Corp. (Pittsburgh, PA) acquired The International Metals Reclamation Co. (INMETCO) from Vale Inco Ltd. of Toronto, Canada. INMETCO operated the sole secondary smelter in North America dedicated to recycling both chromium and nickel from waste materials. The INMETCO smelter, in Ellwood City, PA, has been producing a remelt alloy since 1978 that typically averages 13% chromium and 12% nickel. The remelt alloy was used as a substitute for ferrochromium and ferronickel in the production of stainless steel (Horsehead Holding Corp., 2010).

Ferrosilicon

Silicon ferroalloy consumption is driven by cast iron and steel production, where silicon alloys are used as deoxidizers. Some silicon metal was also used as an alloying agent with iron. On the basis of silicon content, U.S. net production of silicon ferroalloys (ferrosilicon and miscellaneous silicon alloys) was 176,000 t, 27% more than that in 2009. On a gross-weight basis, U.S. net production of ferrosilicon in 2010 (246,000 t) also increased by 27% compared with that of 2009 (table 7). China produced more ferrosilicon than the rest of the world combined and about five times that of the next two major producing countries—Russia and the United States—combined.

Ferrotitanium

Titanium is used in steelmaking for deoxidation, grain-size control, and carbon and nitrogen control and stabilization. During steelmaking, titanium is usually introduced as ferrotitanium because of its lower melting temperature and higher density compared with those of titanium scrap. Steels with relatively high titanium content include interstitial-free, stainless, and high-strength low-alloy steels. Ferrotitanium is usually produced by induction melting of titanium scrap with iron or steel; however, it also is produced directly from titanium mineral concentrates. The standard grades of ferrotitanium are 30% and 70% titanium. U.S. producers of ferrotitanium were Global Titanium Inc. (Detroit, MI), with 10,000 t/yr of ferrotitanium production capacity, and RTI International Metals, Inc. (Canton, OH), with 7,260 t/yr of ferrotitanium and specialty alloy production capacity. The leading ferrotitanium producing countries were China, India, Russia, Ukraine, the United Kingdom, and the United States.

In the United States, reported domestic consumption of titanium products in steel and other alloys was 11,700 t (gross weight), a 25% decrease compared with that of 2009. Increased global steel production in 2010 increased the need for ferrotitanium. Because of increased consumption from steel producers, the average price range for 70%-grade ferrotitanium increased to $3.18 to $3.25 per pound, compared with $2.12 to $2.20 per pound in 2009.

Ferrotungsten

Tungsten is an important alloying element in high-speed and other tool steels, and is used to a lesser extent in some stainless and structural steels. Tungsten can be added to steel melts as (1) ferrotungsten, which is a master alloy containing between 75% and 80% tungsten; (2) tungsten melting base, which is a master alloy containing up to 36% tungsten; (3) tungsten metal scrap; or (4) scheelite ore concentrates (Lassner and Schubert, 1999, p. 307–312; Roskill Information Services Ltd., 2007, p. 167–168, 174, 178–179).

World ferrotungsten production was dominated by China. In 2010, Chinese production increased to an estimated 6,000 t, gross weight, of ferrotungsten, from about 5,000 t in 2009, but remained below the 10,000 t/yr typically produced between 2000 and 2008. Chinese ferrotungsten exports increased by 10% in 2010 to 1,280 t, gross weight, from 1,160 t, gross weight, in 2009 (China Metal Market—Precious & Minor Metals Monthly, 2011; Fang, 2011, p. 8). U.S. reported consumption of ferrotungsten was significantly lower than that of 2009. Ferrotungsten prices increased from those of 2009, with the Platts Metals Week price ranging between $25.50 and $52.00 per kilogram of contained tungsten during the year.

Ferrovanadium

In 2010, China, Russia, and South Africa accounted for 98% of world vanadium mine production. In these three countries, vanadium was primarily recovered from titanium-bearing magnetite ore processed to produce pig iron. The process produces a slag containing 20% to 24% vanadium pentoxide, which can be further processed to ferrovanadium containing 40% to 50% vanadium.

In 2010, vanadium recovery from various industrial waste materials, such as vanadium-bearing fly ash, petroleum residues, pig iron slag, and spent catalysts was the leading source of U.S. vanadium production. A small amount of vanadium was obtained as a coproduct from the mining of uraniferous sandstones on the Colorado Plateau.

The domestic steel industry accounted for the majority of U.S. reported vanadium consumption in 2010, principally in carbon, full alloy and high-strength, low-alloy steels. Ferrovanadium supplied 84% of the 5,000 t of vanadium consumed in the United States; this was a 6% increase compared with the revised figure of 79% for 2009. Steel manufacturing consumed almost all of the ferrovanadium in 2010 (table 4).

Outlook

The near-term trend for domestic ferroalloy consumption was expected to follow closely that of U.S. steel production. Details of the outlook for the steel industry are discussed in the Outlook section of the Iron and Steel chapter of the 2010 USGS Minerals Yearbook, volume I, Metals and Minerals. Crude steel production in the United States increased by 36% to 80.5 Mt in 2010 from that in 2009 (Fenton, 2012; table 1). World raw steel production increased by 14% to 1.42 billion metric tons (Gt) in 2010 from that in 2009, with a 33% increase in North American raw steel production to 109.5 Mt. Raw steel production in China, the leading world producer, increased by 9.5% to about 627 Mt. MEPS (International) Ltd. (2011) forecast that world raw steel production would increase by 5% to 1.49 Gt in 2011 from that in 2010, and by 4.4% in 2012.

Changes in steel production reflect changes in apparent use of steel. According to the World Steel Association (2011), world apparent steel use would increase by 5.9% to 1.36 Gt in 2011 and by 6% to 1.44 Gt in 2012. Domestic apparent steel use was expected to increase by 13% in 2011 to 90.5 Mt, as a result of continued recovery in U.S. manufacturing.

Chromium, manganese, silicon, and other ferroalloy metals are discussed in more detail, including domestic data coverage, outlook, and U.S. Government stockpile information, in the respective mineral commodity chapters in the U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

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TABLE 1
DOMESTIC PRODUCERS OF FERROALLOYS IN 2010

Company	Plant location	Products[1]							
		FeCr	FeMo	FeMn	FeNb	FeSi	FeTi	FeV	SiMn
Bear Metallurgical Co.	Butler, PA		X					X	
CC Metals & Alloys, LLC	Calvert City, KY					X			
Core Metals Group[2]	Bridgeport, AL					X			
Eramet Marietta Inc.	Marietta, OH	X		X					X
Felman Production Inc.	Letart, WV								X
Global Titanium Inc.	Detroit, MI						X		
Globe Metallurgical Inc.[2]	Beverly, OH					X			
Metallurg Vanadium Corp.	Cambridge, OH							X	
Reading Alloys Inc.	Robesonia, PA				X				
RTI International Metals, Inc.	Canton, OH						X		
Stratcor, Inc.	Hot Springs, AR							X	
Thompson Creek Metals Co. Inc.	Langeloth, PA		X						

[1] FeCr, ferrochromium; FeMo, ferromolybdenum; FeMn, ferromanganese; FeNb, ferroniobium; FeSi, ferrosilicon; FeTi, ferrotitanium; FeV, ferrovanadium; SiMn, silicomanganese.

[2] Owned by Globe Specialty Metals.

TABLE 2
GOVERNMENT INVENTORY OF FERROALLOYS, DECEMBER 31, 2010[1, 2]

(Metric tons of alloys unless otherwise specified)

Alloy	Inventory
Ferrochromium:	
High-carbon	95,400
Low-carbon	59,000
Ferromanganese, high-carbon	368,000

[1] Data are rounded to no more than three significant digits.

[2] Data are uncommitted inventory.

Source: Defense Logistics Agency, DLA Strategic Materials.

TABLE 3

REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2010[1,2]

(Metric tons of alloys unless otherwise specified)

		Manganese				
End use	FeB	FeMn	SiMn	FeP	FeSi	FeTi
Steel:						
Carbon and high-strength low-alloy	477	247,000	62,100	3,630	37,100 [3,4,5]	6,370
Stainless and heat-resisting	(3)	8,790	14,200	(3)	46,600 [3]	3,300
Other alloy	(3)	28,900	16,700	(3)	13,100 [3,5]	392
Tool	(3)	(5)	(3)	--	(3)	(5)
Unspecified	279	--	904	735	50,800 [5]	--
Total steel	756	285,000	93,900	4,360	148,000	10,100
Cast irons	(6)	6,970	460	(6)	88,300 [5]	16
Superalloys	34	(7)	--	(6)	(6)	522
Alloys (excluding alloy steels and superalloys)	(6)	705	2,920	(6)	52,200 [4,5]	1,020
Miscellaneous and unspecified	401	(7)	(7)	1,010	177,000 [4]	42
Grand total	1,190	292,000	97,300	5,370	465,000	11,700
Total 2009	1,110 [r]	255,000 [r]	92,800 [r,8]	4,420 [r]	479,000	9,300 [r]
Percentage of 2009	107	115	105	121	97	125
Consumer stocks, December 31	191	30,000 [9]	28,000 [9]	805	14,200	1,410

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] FeB, ferroboron, including other boron materials; FeMn, ferromanganese, including manganese metal; SiMn, silicomanganese; FeP, ferrophosphorus, including other phosphorus materials; FeSi, ferrosilicon, including silicon metal, silvery pig iron, silicon carbide, and inoculant alloys; FeTi, ferrotitanium, including titanium scrap and other titanium materials.

[3] All or part included with "Steel, unspecified."

[4] All or part included with "Cast irons."

[5] All or part included with "Steel, other alloy."

[6] All or part included with "Miscellaneous and unspecified."

[7] All or part included with "Alloys (excluding alloy steels and superalloys)."

[8] Internal evaluation indicates that silicomanganese consumption is considerably understated.

[9] Consumer and producer stocks.

TABLE 4

REPORTED U.S. CONSUMPTION OF FERROALLOYS AS ALLOYING ELEMENTS BY END USE IN 2010[1,2]

(Metric tons of contained elements unless otherwise specified)

End use	FeCr	FeMo	FeNb	FeNi	FeV	FeW
Steel:						
Carbon	4,140	281	1,630	--	821	--
High-strength low-alloy	2,710	117	(3)	(3)	(4)	--
Stainless and heat-resisting	207,000	721	726	11,100	120	(3)
Other alloy	28,300	3,090	(3)	(3)	3,260	(3)
Tool	(4)	(4)	(3)	(3)	(4)	(3)
Unspecified	--	--	1,810	103	--	129
Total	242,000	4,210	4,160	11,200	4,200	129
Cast irons	677	334	--	--	(4)	--
Superalloys	7,480	(5)	1,400	W	6	(3)
Alloys (excluding alloy steels and superalloys)	2,180	126	24	W	(4)	(3)
Miscellaneous and unspecified	--	--	--	220	--	--
Grand total	253,000	4,670	5,590	11,400	4,210	129
Total 2009	226,000[r]	4,170	4,350[r]	9,210[r]	3,910	246
Percentage of 2009	112	112	128	124	108	52
Consumer stocks, December 31	7,250	347	462	821	181	23

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] FeCr, ferrochromium, including other chromium ferroalloys and chromium metal; FeMo, ferromolybdenum, including calcium molybdate; FeNb, ferroniobium, including nickel niobium; FeNi, ferronickel; FeV, ferrovanadium, including other vanadium-carbon-iron ferroalloys; and FeW, ferrotungsten.

[3] Included with "Steel, unspecified."

[4] Included with "Steel, other alloy."

[5] Included with "Alloys (excluding alloy steels and superalloys)."

TABLE 5
FERROALLOY PRICES IN 2010

	High	Low	Average
Chromium:			
Ferrochromium:			
0.05% carbon[1]	242.65	237.86	240.26
0.10% carbon[1]	217.82	213.37	215.60
0.15% carbon[1]	203.24	197.70	200.47
Over 4% carbon:			
49–51% chromium[1]	119.31	115.08	117.20
60–65% chromium[1]	128.42	123.94	126.18
Manganese:			
Medium-carbon ferromanganese[1]	175.00	105.00	129.09
Standard high-carbon ferromanganese[2]	1,600.00	1,290.00	1,403.41
Silicomanganese[3]	73.00	58.00	64.27
Molybdenum:			
Ferromolybdenum[4]	18.69	18.23	18.46
Molybdenum oxide[4]	16.07	15.63	15.85
Silicon:			
50% ferrosilicon[1]	126.00	88.00	109.33
75% ferrosilicon[1]	116.00	77.00	97.18
Silicon metal[1]	165.00	115.00	140.05
Vanadium, ferrovanadium[4]	14.69	14.16	14.42

[1] Cents per pound of contained element.

[2] Dollars per gross ton.

[3] Cents per pound.

[4] Dollars per pound of contained element.

Sources: Platts Metals Week and Ryan's Notes.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF FERROALLOYS AND FERROALLOY METALS IN 2010[1]

Alloy	Imports			Exports		
	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)
Ferroalloys:						
Chromium ferroalloys:						
Ferrochromium containing:						
More than 4% carbon	454,000	261,000	$597,000	6,530	3,150	$7,810
Not more than 4% carbon	XX	XX	XX	2,490	1,060	4,820
More than 3% but not more than 4% carbon	1,170	697	1,290	XX	XX	XX
More than 0.5% but not more than 3% carbon	2,370	1,450	5,320	XX	XX	XX
Not more than 0.5% carbon	49,900	34,300	159,000	XX	XX	XX
Ferrochromium-silicon	17,000	7,210	28,200	106	37	225
Total	524,000	305,000	791,000	9,130	4,250	12,900
Manganese ferroalloys:						
Ferromanganese containing:						
More than 4% carbon	201,000	155,000	237,000	XX	XX	XX
More than 2% but not more than 4% carbon	291	238	629	XX	XX	XX
More than 1% but not more than 2% carbon	85,900	68,400	163,000	XX	XX	XX
Not more than 1% carbon	39,500	33,500	92,800	XX	XX	XX
Ferromanganese, all grades	XX	XX	XX	19,100	XX	27,800
Silicomanganese	297,000	197,000	373,000	9,360	XX	13,100
Total	623,000	454,000	866,000	28,500	XX	40,900
Silicon ferroalloys:						
Ferrosilicon containing:						
More than 55% silicon	XX	XX	XX	18,800	11,600	18,200
More than 55% but not more than 80% silicon and more than 3% calcium	4,410	2,910	9,040	XX	XX	XX
Magnesium ferrosilicon	14,500	6,500	26,000	XX	XX	XX
Ferrosilicon, other[2, 3]	210,000	147,000	307,000	6,590	3,110	11,400
Total	229,000	157,000	342,000	25,400	14,700	29,600
Other ferroalloys:						
Ferrocerium and other pyrophoric alloys	148	XX	3,110	XX	XX	XX
Ferromolybdenum	5,330	3,560	130,000	1,430	978	33,100
Ferronickel	30,200	9,420	186,000	69	31	1,280
Ferroniobium	9,660	XX	237,000	395	XX	4,190
Ferrophosphorus	7,650	XX	4,180	1,030	XX	2,000
Ferrotitanium and ferrosilicon-titanium	2,740	XX	11,500	2,570	XX	12,200
Ferrotungsten and ferrosilicon-tungsten	462	357	11,000	(4)	(4)	11
Ferrovanadium	1,660	1,340	41,100	882	611	18,100
Ferrozirconium	45	XX	246	569	XX	1,200
Ferroalloys, other	8,730	XX	27,900	4,570	XX	9,210
Total	66,600	14,700	652,000	11,500	1,620	81,300
Total ferroalloys	1,440,000	930,000	2,650,000	74,500	20,600	165,000
Metals:						
Chromium (total, all grades)	13,000	XX	148,000	597	XX	18,400
Manganese:						
Metal, including alloys and waste and scrap	XX	XX	XX	3,660	XX	10,300
Unwrought	34,600	XX	91,800	XX	XX	XX
Other manganese, wrought	617	XX	3,110	XX	XX	XX
Silicon:						
Less than 99% silicon	29,200	27,600	66,000	12,600	12,200	33,700
Less than 99.99% but not less 99% silicon	141,000	138,000	372,000	3,330	3,300	8,390
Not less than 99.99% silicon	4,870	XX	309,000	49,900	XX	2,660,000
Total metals	223,000	166,000	990,000	70,100	15,500	2,730,000
Grand total	1,670,000	1,100,000	3,640,000	145,000	36,100	2,890,000

See footnotes at end of table.

TABLE 6—Continued

U.S. IMPORTS FOR CONSUMPTION AND EXPORTS OF FERROALLOYS AND FERROALLOY METALS IN 2010[1]

XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes less than 55% silicon and 55% to 80% silicon, other.

[3] Includes imports of ferrosilicon containing 80% to 90% silicon and more than 90% silicon.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2006	2007	2008	2009	2010[e]
Albania, electric furnace, ferrochromium	17,040	--	11,916	7,556	8,000
Argentina, electric furnace:					
Ferrosilicon[e]	24,400	15,000	10,400	11,300	11,000
Silicomanganese	9,268	8,917	9,172	6,644	6,000
Total[e]	33,700	23,900	19,600	17,900	17,000
Armenia, electric furnace:					
Ferromolybdenum	4,865	5,977	5,325	5,144	5,126 [6]
Ferrotungsten	42	45	45 [e]	40 [e]	40
Total	4,907	6,022	5,370	5,180	5,170
Australia, electric furnace:[e]					
Ferromanganese	125,000	115,000	147,000	87,000	136,000
Silicomanganese	120,000	110,000	125,000	74,000	131,000
Silicon metal	35,000	35,000	35,000	30,000	30,000
Total	280,000	260,000	307,000	191,000	297,000
Austria, electric furnace:[e]					
Ferronickel, including ferronickel molybdenum	2,250 [r]	2,250 [r]	2,000 [r]	1,750 [r]	1,500
Other	3,600	3,600	3,600	2,000	2,000
Total	5,850 [r]	5,850 [r]	5,600 [r]	3,750 [r]	3,500
Bhutan, electric furnace, ferrosilicon, exports[e]	21,600 [r]	40,300 [r]	30,800 [r]	90,800 [r]	54,500
Bosnia and Herzegovina, electric furnace, net exports:[e]					
Ferrosilicon	1,300	860	640	470	870
Silicon metal	15,200	11,600	12,400	11,000	17,300
Total	16,500	12,500	13,000	11,500	18,200
Brazil, electric furnace:					
Ferrochromium[7]	166,577	195,890	194,324 [r]	131,048 [r]	170,000 [p]
Ferrochromium silicon	11,600 [e]	11,600 [e]	11,507	11,510	11,600 [p]
Ferromanganese	280,770	205,000 [r]	190,000 [r]	75,000 [r, e]	103,000 [p, 6]
Ferronickel	39,256 [r]	39,672 [r]	36,544 [r]	37,708 [r]	33,860 [p, 6]
Ferroniobium (ferrocolumbium)	41,566	52,442	53,839 [r]	34,746 [r]	35,000 [p]
Ferrosilicon[e]	146,000	146,000	144,832 [6]	145,000	145,000
Ferrotitanium	5,000 [r, e]	4,988 [r]	4,002 [r]	482 [r, e]	498 [p]
Silicomanganese[e]	292,230 [6]	214,000	198,000	79,000 [r]	107,000
Silicon metal[e]	133,000	133,000	131,940 [6]	132,000	132,000
Other[e]	19,500	19,500	19,344 [6]	19,350	19,400
Total	1,135,499 [r]	1,022,092 [r]	984,332 [r]	665,844 [r]	757,000
Bulgaria, electric furnace, ferrosilicon[e]	10,000	10,000	6,000 [r]	3,000 [r]	--
Canada, electric furnace:[e]					
Ferroniobium (ferrocolumbium)	6,298 [6]	6,571 [6]	6,644 [6]	7,000 [r]	7,000
Ferrosilicon	35,000	35,000	35,000	27,200 [r]	35,400
Ferrovanadium	1,000	1,000	1,000	900	900
Silicon metal	30,000	30,000	50,000	30,000	30,000
Total	72,300	72,600	92,600	65,100 [r]	73,300
Chile, electric furnace, ferromolybdenum	14,001	14,828	16,918	10,820 [6]	12,485 [6]
China:[e]					
Blast furnace:					
Ferromanganese	600,000	600,000	600,000	350,000 [r]	350,000
Other	60,000	50,000	50,000	30,000	30,000
Total, blast furnace	660,000	650,000	650,000	380,000 [r]	380,000

See footnotes at end of table.

TABLE 7—Continued
FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2006	2007	2008	2009	2010[e]
China—Continued:[e]					
Electric furnace:					
Ferrochromium	1,000,000	1,300,000	1,500,000	1,810,000 [r]	2,000,000
Ferromanganese	1,400,000	1,930,000	2,100,000	2,070,000 [r]	2,300,000
Ferromolybdenum	90,000	60,000	80,000	90,000	90,000
Ferronickel and high nickel pig iron[8]	390,000	845,000	590,000	600,000	900,000
Ferrosilicon	4,020,000	4,710,000	4,900,000	5,100,000 [r]	5,300,000
Ferrotitanium	4,000 [r]	10,000 [r]	14,000 [r]	300 [r]	500
Silicomanganese	3,600,000	4,340,000	5,000,000	5,430,000 [r]	5,700,000
Silicon metal	900,000	950,000	980,000	1,230,000 [r]	1,500,000
Other	2,630,000	3,560,000	3,230,000	6,620,000 [r]	7,600,000
Total, electric furnace	14,000,000	17,700,000	18,400,000	23,000,000 [r]	25,400,000
Total, blast and electric furnaces	14,700,000	18,400,000 [r]	19,000,000	23,300,000 [r]	25,800,000
Colombia, electric furnace, ferronickel	151,967 [r]	145,282 [r]	126,638 [r]	153,628 [r]	145,239 [6]
Czech Republic, electric furnace, other[e]	2,800	2,800	2,800	--	--
Dominican Republic, electric furnace, ferronickel	76,659	75,067	47,408	--	-- [6]
Egypt, electric furnace:[e]					
Ferromanganese	30,000	30,000	30,000	30,000	30,000
Ferrosilicon	50,000	48,000 [r]	59,000 [r]	78,000 [r]	78,000
Total	80,000	78,000 [r]	89,000 [r]	108,000 [r]	108,000
Finland, electric furnace, ferrochromium	243,350	241,760	233,550	123,310	125,000
France, electric furnace:[e]					
Ferromanganese	137,000	144,000	46,600	46,000	138,000
Ferrosilicon	34,000 [r]	31,000 [r]	30,000 [r]	18,300 [r]	27,000
Silicomanganese	63,300	65,400	60,200	54,100	54,000
Silicon metal	100,000 [r]	120,000 [r]	118,000 [r]	80,000 [r]	112,000
Other	60,000	60,000	60,000	60,000	60,000
Total	394,000 [r]	420,000 [r]	315,000 [r]	258,000 [r]	391,000
Georgia, electric furnace:					
Ferromanganese	5,130	5,000 [e]	5,000 [e]	NA [r]	NA [6]
Silicomanganese	116,945	120,000 [e]	120,000 [e]	112,016 [r]	203,464 [6]
Total	122,075	125,000 [e]	125,000 [e]	112,016 [r]	203,464 [6]
Germany, electric furnace:					
Ferrochromium	26,710	22,030	26,960	13,667	20,000
Silicon metal	35,500	35,245	35,000 [e]	20,000 [e]	35,000
Other[e, 9]	24,100	5,000	5,000	--	--
Total	86,310	62,275	66,960	33,667	55,000
Greece, electric furnace, ferronickel	88,000 [e]	90,000 [e]	87,664	42,423	66,000
Iceland, electric furnace, ferrosilicon	113,798	110,000 [e]	100,000 [e]	112,993 [r]	114,231 [6]
India, electric furnace:[10]					
Ferroaluminum	9,947	9,377	8,170	7,017	7,000
Ferroboron	80	80	83	90	95
Ferrochromium[11]	634,200 [r]	820,000 [r]	750,000 [r]	873,385 [r]	850,000
Ferromanganese	296,726	391,210	384,577	389,465	390,000
Ferromolybdenum	3,120	2,899	2,162	2,822	3,000
Ferronickel magnesium	97	122	221	209	210
Ferrosilicomagnesium	11,387	13,525	13,400	17,132	17,000
Ferrosilicon	68,000 [r]	80,000 [r]	92,000 [r]	101,337 [r]	101,000

See footnotes at end of table.

TABLE 7—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2006	2007	2008	2009	2010[e]
India, electric furnace—Continued:[10]					
Ferrosilicozirconium	178	109	87	120	150
Ferrotitanium	1,761	1,937	1,661	2,379	2,200
Ferrotungsten	54	51	150	150	160
Ferrovanadium	1,139	1,585	1,501	1,769	1,800
Silicomanganese	782,962	911,402	891,458	1,099,838	1,000,000
Total	1,809,651[r]	2,232,297[r]	2,145,470[r]	2,495,713[r]	2,370,000
Indonesia, electric furnace:					
Ferromanganese[e]	12,000	12,000	12,000	12,000	12,000
Ferronickel	72,300	92,500	87,800	62,700[r]	93,300
Silicomanganese[e]	5,000	6,000	7,000	7,000	8,000
Total	89,300	110,500	106,800	81,700[r, e]	113,000
Iran, electric furnace:[e]					
Ferrochromium	7,000	8,000	8,000	8,000	8,000
Ferromanganese	--[r]	--[r]	--[r]	--[r]	--[6]
Ferrosilicon	45,000	45,000	45,000	45,000	45,000
Total	52,000	53,000	53,000	53,000	53,000
Italy, electric furnace:[e]					
Ferromanganese	4,500	4,800	8,500	5,500	17,000
Silicomanganese	33,500	37,000	25,500	17,000	23,000
Other[12]	10,000	10,000	10,000	10,000	10,000
Total	48,000	51,800	44,000	32,500	50,000
Japan, electric furnace:					
Ferrochromium[13]	13,056	12,016	13,888	7,698[r]	16,208[6]
Ferromanganese	406,162	420,151	431,181	361,375	453,265[6]
Ferromolybdenum	4,229	4,573	4,554	3,598	4,615[6]
Ferronickel	335,884	351,503	301,361	284,884	348,420[6]
Ferrotitanium	NA	NA	NA	NA	NA
Ferrovanadium	2,042[r]	3,205[r]	3,477	2,560	4,190[6]
Silicomanganese	59,424	52,901	58,884	49,205	49,865[6]
Other[14]	13,123[r]	13,982[r]	14,478	12,957	16,374[6]
Total	833,920	858,331	827,823[r]	722,277[r]	892,937[6]
Kazakhstan, electric furnace:					
Ferrochromium	1,190,673[r]	1,307,536	1,220,315	1,173,286[r]	1,250,000
Ferrochromium silicon	117,607[r]	145,695	133,828	60,829[r]	150,000
Ferromanganese[e]	--[r]	--[r]	--[r]	--[r]	--
Ferrosilicon	85,924[r]	59,886	54,964	33,100[r]	20,000
Silicomanganese	218,323[r]	188,445	179,939	200,374[r]	215,000[6]
Silicon metal	--	--	--	--	1,500
Other[e]	--[r]	--[r]	--[r]	--[r]	--
Total	1,612,527[r]	1,701,562[r]	1,589,046[r]	1,467,589[r]	1,640,000
Korea, North, electric furnace, other[e]	10,000	10,000	10,000	10,000	10,000
Korea, Republic of, electric furnace:					
Ferromanganese	169,202	209,321	251,125	250,000[r, e]	250,000
Ferronickel	--	--	6,600	56,911[r]	55,215[6]
Silicomanganese	94,119	105,607	76,184	80,000[r, e]	80,000
Other	3,653	4,224	4,000[e]	--[r]	--
Total	266,974	319,152	337,909	387,000[r]	385,000

See footnotes at end of table.

TABLE 7—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2006	2007	2008	2009	2010[e]
Kosovo, ferronickel	--	3,500 [r, 15]	24,300 [r, 15]	27,700 [r, e]	30,400
Macedonia, electric furnace:					
Ferromanganese	--	--	12,623	--	-- [6]
Ferronickel	47,600 [r]	66,600 [r]	65,300 [r]	52,200 [r, e]	60,900
Ferrosilicon	59,023	34,215	42,674	7,657	67,000
Silicomanganese	--	70,472	54,931	--	-- [6]
Total	106,623 [r]	171,287 [r]	175,528 [r]	59,857 [r]	128,000
Mexico, electric furnace:[16]					
Ferromanganese	62,485	74,578	97,366	42,492	42,000
Silicomanganese	97,457	109,286	114,320	85,065	85,000
Total	159,942	183,864	211,686	127,557	127,000
New Caledonia, electric furnace, ferronickel	162,400	151,100	144,300	147,200	145,000 [6]
Norway, electric furnace:[e]					
Ferromanganese	245,000	245,000	309,000	205,000	297,000
Ferrosilicon	93,000	217,000	250,575 [6]	207,337 [6]	210,000
Silicomanganese	230,000	225,000	252,000	200,000	249,000
Silicon metal	100,000	145,782 [6]	180,135 [6]	169,643 [6]	170,000
Other[9]	15,000	15,000	15,000	15,000	15,000
Total	683,000	848,000	1,010,000	797,000	941,000
Peru, electric furnace, ferrosilicon[e]	600	600	600	600	600
Poland:					
Blast furnace, ferromanganese	4,100	2,100	8,500 [r]	1,700 [r, e]	2,000
Electric furnace:					
Ferrosilicon	13,034	58,538	56,031	9,685 [r]	10,000
Silicomanganese	3,310	15,600	25,100 [r]	14,000 [r, e]	15,000
Total, electric furnace	16,344	74,138	81,131 [r]	23,700 [r]	25,000
Total, blast and electric furnaces	20,444	76,238	89,631 [r]	25,400 [r]	27,000
Romania, electric furnace:					
Ferrochromium	--	--	W	W	W
Ferromanganese	3,329	--	--	--	--
Silicomanganese	53,085	26,868	10,000	--	20,000
Total	56,414	26,868	10,000	W [r]	20,000
Russia:[e]					
Blast furnace:					
Ferromanganese	130,000	120,000	110,000	88,000 [r, 6]	171,600 [6]
Ferrophosphorus	3,500	3,500	3,500	3,000	3,600
Spiegeleisen	7,000	7,000	7,000	6,500	5,500
Total, blast furnace	141,000	131,000	121,000	97,500 [r]	181,000
Electric furnace:					
Ferrochromium	600,000	570,000	490,000	378,000 [6]	414,000
Ferrochromium silicon	4,000	4,000	4,000	3,500	4,200
Ferronickel:					
High-nickel[6, 17]	16,085	19,031	17,971	17,489	19,763
Other[6, 18]	12,340	12,840	13,440	14,040	14,600
Ferroniobium (ferrocolumbium)	--	121	121	120	121
Ferrosilicon	882,300 [6]	896,100 [6]	850,000	745,000	916,000
Ferrotitanium	NA	NA	NA	NA	4,000

See footnoets at end of table.

TABLE 7—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2006	2007	2008	2009	2010^{e}
Russia, electric furnace—Continued:					
Ferrovanadium	11,000	12,000	12,000	8,029 $^{r, 6}$	13,507 ^{6}
Silicomanganese	40,000	40,000	40,000	98,700 $^{r, 6}$	147,900 ^{6}
Silicon metal	54,500	54,000	54,000	23,900 ^{r}	48,700
Other	22,000	22,000	22,000	20,000	18,000
Total, electric furnace	1,640,000	1,630,000	1,500,000	1,310,000 ^{r}	1,600,000
Total, blast and electric furnaces	1,780,000	1,760,000	1,620,000	1,410,000 ^{r}	1,780,000
Saudi Arabia, electric furnace, other^{e}	85,000	85,000	90,000	80,000 ^{r}	90,000
Slovakia, electric furnace:					
Ferrochromium	19	--	--	--	--
Ferromanganese	59,391	74,065	61,194	21,000 $^{r, e}$	25,000
Ferrosilicon	16,155	8,583	10,844	8,622	37,034 ^{6}
Silicomanganese	59,128	71,587	59,940	32,000 $^{r, e}$	35,000
Other^{e}	5,000	5,000	--	--	--
Total	139,693	159,235	131,978	61,600 ^{r}	97,000
Slovenia, electric furnace, ferrosilicon	12,550	6,000 ^{e}	--	--	--
South Africa, electric furnace:					
Ferrochromium	3,030,000	3,551,983 ^{r}	3,268,659 ^{r}	2,346,131 ^{r}	3,607,132 ^{6}
Ferromanganese	656,235	698,654	503,000	260,000 ^{e}	530,000 ^{6}
Ferronickel, high-nickel	133	6,667	5,733	1,067	1,040 ^{6}
Ferrosilicon	148,900	140,000	135,000	120,000 ^{e}	130,000
Ferrovanadium^{e}	18,000	19,000	19,000	17,000	18,000
Silicomanganese^{e}	247,000	302,000	233,000	110,000	230,000
Silicon metal	58,000 ^{r}	53,000 ^{r}	55,000 ^{r}	38,000 $^{r, e}$	53,200
Total	4,158,268 ^{r}	4,771,304 ^{r}	4,219,392 ^{r}	2,892,198 ^{r}	4,570,000
Spain, electric furnace:^{e}					
Ferromanganese	148,000 ^{r}	155,000 ^{r}	163,000 ^{r}	68,000 ^{r}	152,000
Ferrosilicon	67,000	71,000	74,000 ^{r}	44,000 ^{r}	64,400
Silicomanganese	145,000 ^{r}	153,000 ^{r}	160,000 ^{r}	67,000 ^{r}	150,000
Silicon metal	32,000	32,000	33,000 ^{r}	23,000 ^{r}	32,500
Other	5,000	5,000	5,000	5,000	5,000
Total	397,000 ^{r}	416,000 ^{r}	435,000 ^{r}	207,000 ^{r}	404,000
Sweden, electric furnace:					
Ferrochromium	136,374	124,403	117,053	31,345	36,000
Ferrosilicon^{e}	4,000	5,000	5,000	5,000	5,000
Total	140,374	129,403	122,053	36,345	41,000
Thailand, electric furnace, silicon metal	--	--	--	NA	22,500
Turkey, electric furnace:					
Ferrochromium	67,975	69,730	79,840 ^{r}	41,028	60,000
Ferrosilicon^{e}	2,000 ^{r}	5,000	4,500 ^{r}	4,000	4,000
Total	69,975 ^{r}	74,730	84,340 ^{r}	45,028	64,000
Ukraine:					
Blast furnace:					
Ferromanganese	30,000	26,700	16,000	--	-- ^{6}
Spiegeleisen^{e}	4,450 ^{r}	4,730 ^{r}	2,000 ^{r}	-- ^{r}	--
Total, blast furnace^{e}	34,500 ^{r}	31,400 ^{r}	18,000 ^{r}	-- ^{r}	--

See footnotes at end of table.

TABLE 7—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1, 2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3, 4, 5]	2006	2007	2008	2009	2010[e]
Ukraine, electric furnace—Continued:					
Ferromanganese	373,000	368,000	362,400[r]	129,400	280,100[6]
Ferronickel	79,338	79,530	89,825	61,449	62,000
Ferrosilicon	169,000	218,000	152,800	150,300	195,500[6]
Ferrotitanium	NA	NA	NA	NA	NA
Silicomanganese	1,168,000	1,281,000	894,900[r]	741,900	940,400[6]
Other[e]	22,200[r]	23,700[r]	23,000[r]	23,900[r]	28,500[6]
Total, electric furnace	1,811,538[r]	1,970,230[r]	1,522,925[r]	1,106,949[r]	1,506,500[6]
Total, blast and electric furnaces	1,845,988[r]	2,001,660[r]	1,540,925[r]	1,106,949[r]	1,506,500[6]
United Kingdom, electric furnace, ferrotitanium	NA	NA	NA	NA	NA
United States, electric furnace:					
Ferrochromium[19]	W	W	W	W	W
Ferromanganese[20]	W	W	W	W	W
Ferroniobium (ferrocolumbium)	NA	NA	NA	NA	NA
Ferrosilicon[21]	194,000	220,000	248,000	194,000[r]	246,000[6]
Ferrotitanium	NA	NA	NA	NA	NA
Silicon metal[21]	W	W	W	W	W
Other[22]	W	W	W	W	W
Total	194,000	220,000	248,000	194,000[r]	246,000[6]
Uruguay, electric furnace, ferrosilicon[e]	200	200	200	200	200
Venezuela, electric furnace:[e]					
Ferromanganese	15,000	15,000	15,000	15,000	15,000
Ferronickel[6]	75,313	68,506	42,300	40,113	40,150
Ferrosilicon	95,000[r]	94,000[r]	88,000[r]	52,100[r]	76,800
Silicomanganese	35,000	35,000	35,000	35,000	35,000
Total	220,000[r]	213,000[r]	180,000[r]	142,000[r]	167,000
Zimbabwe, electric furnace:					
Ferrochromium	200,673	187,327	145,430	72,223	150,000
Ferrochromium silicon	1,024	3,097	1,612	603	--
Total	201,697	190,424	147,042	72,826	150,000
Grand total:	32,800,000	38,000,000[r]	37,300,000[r]	38,000,000[r]	44,300,000
Of which:					
Blast furnace:					
Ferromanganese	764,000	749,000	735,000[r]	440,000[r]	524,000
Spiegeleisen	11,500[r]	11,700[r]	9,000[r]	6,500[r]	5,500
Other[23]	63,500	53,500	53,500	33,000	33,600
Total, blast furnace	839,000[r]	814,000	797,000[r]	479,000[r]	563,000
Electric furnace:					
Ferrochromium[24]	7,330,000[r]	8,410,000[r]	8,060,000[r]	7,020,000[r]	8,710,000
Ferrochromium silicon	134,000[r]	164,000	151,000	76,400[r]	166,000
Ferromanganese	4,430,000[r]	5,100,000[r]	5,130,000[r]	4,070,000[r]	5,170,000
Ferromolybdenum	116,000[r]	88,300[r]	109,000[r]	112,000[r]	115,000
Ferronickel[17, 18]	1,550,000[r]	2,050,000[r]	1,690,000[r]	1,600,000[r]	2,020,000
Ferroniobium (ferrocolumbium)	47,900	59,100	60,600[r]	41,900[r]	42,100
Ferrosilicon	6,410,000[r]	7,310,000[r]	7,430,000[r]	7,310,000[r]	7,890,000
Ferrovanadium[e]	33,200[r]	36,800[r]	37,000	30,300[r]	38,400
Silicomanganese	7,470,000[r]	8,490,000[r]	8,630,000[r]	8,590,000[r]	9,480,000

See footnotes at end of table.

TABLE 7—Continued

FERROALLOYS: WORLD PRODUCTION, BY COUNTRY, FURNACE TYPE, AND ALLOY TYPE[1,2]

(Metric tons, gross weight)

Country, furnace type, and alloy type[3,4,5]	2006	2007	2008	2009	2010[e]
Grand total, electric furnace–Continued:					
Silicon metal	1,490,000 [r]	1,600,000 [r]	1,680,000 [r]	1,790,000 [r]	2,180,000
Grand total–Continued:					
Of which:					
Other[25]	2,960,000 [r]	3,890,000	3,560,000 [r]	6,910,000 [r]	7,910,000
Total, electric furnace	32,000,000	37,200,000 [r]	36,500,000 [r]	37,500,000 [r]	43,700,000

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through October 7, 2011.

[3] In addition to the countries listed, ferrotungsten is produced in China, Russia, and Vietnam; Austria, China, and Germany are thought to have produced ferroniobium (ferrocolumbium); and Iran is thought to have produced ferromolybdenum and silicomanganese, but production information is inadequate for the formulation of estimates of output levels.

[4] To the extent possible, ferroalloy production of each country has been separated according to the furnace from which production is obtained; production derived from metallothermic operations is included with electric furnace production.

[5] To the extent possible, ferroalloy production of each country has been separated to show the following individual major types of ferroalloys: ferrochromium, ferrochromium silicon, ferromanganese, ferromolybdenum, ferronickel, ferroniobium (ferrocolumbium), ferrosilicon, ferrovanadium, silicomanganese, silicon metal, and spiegeleisen. Ferroalloys other than those listed that have been identified specifically in sources, as well as those ferroalloys not identified specifically, but which definitely exclude those listed previously in this footnote, have been reported as "Other." Where one or more of the individual ferroalloys listed separately in this footnote have been inseparable from other ferroalloys owing to a nation's reporting system, deviations are indicated by individual footnotes.

[6] Reported figure.

[7] Includes high- and low-carbon ferrochromium.

[8] China currently makes several different types of ferronickel. These products range from a low-nickel pig iron (8.5%–9.0% nickel) to high-nickel ferronickel carbonyl powder (70%–80% nickel). The gross weight figures are based on average estimated content ranging from 20%–25% nickel.

[9] Includes, if any, ferrochromium silicon, ferronickel, and silicomanganese.

[10] Reported on a fiscal-year basis, which is from April 1 to March 31.

[11] Includes charge chrome and ferrochrome.

[12] Excludes calcium-silicon.

[13] Includes high- and low-carbon ferrochromium and ferrochromium silicon.

[14] Includes calcium-silicon, ferrocolumbium, and other ferroalloys.

[15] On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

[16] Salable products from Cía Minera Autlán S.A. de C.V.

[17] Low-iron ferronickel containing greater than 85% nickel.

[18] Includes ferronickel chromium and Ni-resist cast iron produced from scrap.

[19] U.S. output of ferrochromium includes chromium metal, high- and low-carbon ferrochromium, ferrochromium silicon, and other chromium materials.

[20] U.S. output of ferromanganese includes silicomanganese.

[21] Net production.

[22] May include ferroboron, ferrocolumbium, ferromolybdenum, ferrophosphorus, ferrotitanium, ferrovanadium, nickel columbium, and silvery pig iron.

[23] Includes ferrophosphorus and data contained in "Blast furnace: Other."

[24] Ferrochromium includes ferrochromium silicon, if any, for Japan, South Africa, and the United States.

[25] Includes ferroaluminum, ferroboron, ferronickel magnesium, ferrosilicon magnesium, ferrosilicozirconium, ferrotitanium, and ferrotungsten.

FLUORSPAR

By M. Michael Miller

Domestic survey data and tables were prepared by Samir Hakim, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, there was no primary fluorspar production in the United States, although a small amount of fluorspar was recovered as a byproduct of limestone quarrying in Illinois and was screened and sold as metallurgical grade. As the U.S. economy showed signs of recovery, fluorspar consumption rebounded in 2010, recovering about one-half of the large decrease reported in 2009. The bulk of U.S. consumption was supplied by imports and by small amounts of byproduct synthetic fluorspar produced from industrial waste streams. Byproduct fluorosilicic acid (FSA) production from some phosphoric acid producers supplemented fluorspar as a domestic source of fluorine but was not included in fluorspar production or consumption calculations.

According to the U.S. Census Bureau, U.S. trade in fluorspar, cryolite, and major fluorochemicals increased after the steep decline recorded in 2009 (tables 1, 4–6). Fluorspar is used directly or indirectly to manufacture such products as aluminum, gasoline, insulating foams, plastics, refrigerants, steel, and uranium fuel. Most fluorspar consumption and trade involve either acid grade (also called acidspar), which is greater than 97% calcium fluoride (CaF_2), or subacid grade, which is 97% or less CaF_2. Subacid grade includes metallurgical and ceramic grades and is commonly called metallurgical grade or metspar.

Production

In 2010, small amounts of byproduct fluorspar were produced in Illinois by a single company, but data were not collected on quantities produced. There is no U.S. Geological Survey (USGS) data survey for synthetic fluorspar produced in the United States. FSA is produced as a byproduct from the processing of phosphate rock into phosphoric acid. Domestic production data for FSA were developed by the USGS from a voluntary canvass of U.S. phosphoric acid operations known to recover FSA. Of the five FSA operations surveyed, responses were received from four plants, representing 93% of the total sold or used by producers. Production and sales data for the one nonrespondent were estimated based on prior year company data.

In 2010, there were three companies producing marketable byproduct FSA at phosphoric acid plants (part of a phosphate fertilizer operation). J.R. Simplot Co., Mosaic Fertilizer (a subsidiary of The Mosaic Co.), and PCS Phosphate Co. Inc. operated five plants in Florida, Louisiana, North Carolina, and Wyoming that produced marketable FSA. Production of byproduct FSA was 71,600 metric tons (t) (100% basis H_2SiF_6), and quantities sold or used totaled 72,600 t (equivalent to about 128,000 t of fluorspar grading 92% CaF_2) valued at about $10.4 million.

Some synthetic fluorspar was recovered as a byproduct of petroleum alkylation, stainless steel pickling, and uranium processing. The majority of the marketable product was estimated to come from uranium processing, but the actual amount of synthetic fluorspar recovered is unknown.

Hastie Mining and Trucking Co. (Cave-In-Rock, IL), Core Metals Group (Aurora, IN), and Seaforth Mineral & Ore Co. Inc. (East Liverpool, OH) marketed screened and dried imported acid- and metallurgical-grade fluorspar. Hastie Mining also screened and sold small amounts of byproduct fluorspar from the company's limestone quarry operation.

Hastie Mining encountered additional delays in developing its Klondike II fluorspar mine in Kentucky. Development work continued but was slowed while the company waited for a road construction permit. The company installed a heavy-media separation plant, which because of the relatively simple mineralogy of the deposit was expected to be able to produce acid-grade fluorspar without the need for flotation processing. The company owns a flotation mill near Salem, KY, but it had been vandalized while it was idle, and renovation work would be required before it could be made operational. Originally, planned output from the Klondike II project was for combined acidspar and metspar production totaling 50,000 metric tons per year (t/yr). New plans called for production of large quantities of acidspar via the heavy-media plant with an ultimate goal of producing in excess of 200,000 t/yr. Production startup was expected in early 2012 (Don Hastie, Hastie Mining & Trucking Co., oral commun., March 16, 2011).

Consumption

Domestic consumption data were developed by the USGS from a quarterly consumption survey of two large consumers that provide data on hydrofluoric acid (HF) consumption and four distributors that provide data on the merchant market (metallurgical and other uses). Complete quarterly data were received from the two HF producers, while partial data were received from the four distributors, with estimates made for nonrespondents. These responses and estimates accounted for 100% of the reported consumption in table 2.

Industry practice has established three grades of fluorspar—acid grade, containing more than 97% CaF_2; ceramic grade, containing 85% to 95% CaF_2; and metallurgical grade, normally containing 60% to 85% CaF_2. Fluorspar grades are defined by the intended use, but these grades are essentially just ranges derived from customer and supplier specifications. For reasons ranging from availability to economics to process changes, U.S. consumers have been moving toward the use of higher quality fluorspar. For example, welding rod manufacturers may use acid-grade fluorspar rather than ceramic grade, and some steel mills use ceramic or acid grade rather than metallurgical grade.

Total reported U.S. fluorspar consumption increased by 12% in 2010 compared with that of 2009 (table 2). Because of the closure of the single aluminum fluoride (AlF_3) producer in 2008, consumption data for the two HF producers has been combined with "Other" uses in table 2 to avoid disclosing company proprietary data.

Acid-grade fluorspar, which accounted for 94% of the total U.S. fluorspar consumption, was used primarily as a feedstock in the manufacture of HF. Two companies reported fluorspar consumption for the production of HF in 2010—E.I. du Pont de Nemours & Co. Inc. (DuPont) and Honeywell International Inc. Fluorspar consumption for HF production increased substantially compared with that of 2009. Since most acid-grade fluorspar is converted to HF before consumption, it is necessary to discuss HF uses and markets in order to properly analyze fluorspar consumption.

The leading use of HF was for the production of a wide range of fluorocarbon chemicals, including hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs), fluoroelastomers, and fluoropolymers. Production of these compounds accounted for about 75% of domestic HF consumption and 40% of world HF consumption. Major U.S. producers were Arkema Inc., DuPont, Great Lakes Chemical Corp., Honeywell, Mexichem Fluor, Inc. (formerly Ineos Fluor Americas LLC), MDA Manufacturing Ltd., and Solvay Solexis Inc.

Internationally, acid-grade fluorspar was used in the production of AlF_3 and cryolite (Na_3AlF_6), which are the main fluorine compounds used in aluminum smelting. Alumina is dissolved in a bath that consists primarily of molten Na_3AlF_6, AlF_3, and fluorspar to allow electrolytic recovery of aluminum. Fluorine losses are replaced entirely by the addition of AlF_3, the majority of which will react with excess sodium from the alumina to form Na_3AlF_6. Most AlF_3 is produced directly from acid-grade fluorspar or from byproduct FSA. The United States ceased production of AlF_3 in fall 2008 when Alcoa World Alumina LLC (a business unit of Alcoa Inc.) closed its Point Comfort, TX, production facility. The AlF_3 requirements of U.S. aluminum industry are now met through imports (table 8).

The merchant fluorspar market in the United States included sales of metallurgical- and acid-grade material mainly to steel mills, where it was used primarily as a fluxing agent to increase the fluidity of the slag. Sales were also made to smaller markets such as cement plants, foundries, glass and ceramics plants, and welding rod manufacturers in railcar, truckload, and less-than-truckload quantities. Complete data on merchant fluorspar sales cannot be shown because consumption of acid-grade fluorspar for HF production has been combined with other uses in table 2 to prevent disclosure of company proprietary data. In 2010, merchant sales (excluding acid-grade for other uses) increased by 40% compared with those of 2009. During the past 20 to 30 years, fluorspar usage in such industries as steel and glass has declined because of product substitutions or changes in industry practices.

In 2009, U.S. steel production decreased by 36% (33.2 Mt) compared with that of 2008, and raw steel capacity utilization at U.S. steel mills averaged only 51% for the year. In 2010, demand picked up significantly; steel production increased by 38% (22.4 Mt) to 80.6 Mt, and raw steel capacity utilization averaged 70% (Fenton, 2011; World Steel Association, undated). In the United States, consumption of fluorspar in metallurgical markets (mainly steel) increased by 40% compared with that of 2009. Consumption in this sector was 72% metallurgical grade and 28% acid grade.

In the United States, FSA is used primarily for water fluoridation, but it may also be used as a metal surface treatment and cleaner and for pH adjustment in industrial textile processing or laundries. It can also be used in the processing of hides, for hardening masonry and ceramics, and in the manufacture of other chemicals. In 2010, byproduct FSA sold for water fluoridation was 67,100 t valued at $8.92 million, and about 5,600 t valued at $1.47 million was sold or used for other uses.

Stocks

Data for stocks were available from some fluorspar distributors and HF producers. Known consumer and distributor stocks at the end of 2010 totaled 121,000 t. This represented an 18% increase in known consumer and distributor stocks from yearend 2009. The last sales from the National Defense Stockpile were made in 2006, and Government stocks of fluorspar were zero.

Transportation

The United States depends on imports for most of its fluorspar supply. Metallurgical-grade fluorspar is shipped routinely as lump or gravel, with the gravel passing a 75-millimeter (mm) sieve and not more than 10% by weight passing a 9.5-mm sieve. Acid-grade fluorspar is shipped in the form of damp filtercake that contains 7% to 10% moisture to facilitate handling and to reduce dust. This moisture is removed by heating the filtercake in rotary kilns or other dryers before treating with sulfuric acid to produce HF. Acid-grade imports from China and South Africa are usually shipped by ocean freight using bulk carriers of 10,000-t to 50,000-t deadweight capacity; ships in this size range are termed "handymax." Participants negotiate freight levels, terms, and conditions. Some acid grade and ceramic grade is marketed in bags for small users and shipped by truck.

According to the Baltic dry index, which tracks worldwide international shipping prices of handymax, panamax, and capesize dry bulk carriers, ocean freight rates fluctuated during 2010 but remained low, especially compared with the highs reached in 2008. The Baltic dry index began the year above 3,100 but by yearend the index was below 1,700 indicating demand for shipping was still low (Bloomberg L.P., 2011). The low shipping rates benefited fluorspar buyers who could take advantage of low fluorspar prices and low ocean freight rates.

Prices

Acidspar prices for the two major exporting countries, China and Mexico, stabilized in 2010 and at yearend were essentially unchanged from yearend 2009. The price range for low-arsenic acidspar from Mexico, however, did decrease slightly and the price of acidspar from South Africa increased compared with that of 2009. With the rebound in world steel production, the price range for Mexican metspar narrowed to $170 to $200 per metric ton, up from $140 to $195 per ton the previous year (table 3).

Foreign Trade

In 2010, U.S. exports of fluorspar totaled 17,900 t—an increase of 27% compared with those of 2009 (table 4). With the disposal of all fluorspar stocks in the National Defense Stockpile and only a small amount of mined fluorspar, exports are likely reexports of imported material. The leading recipients of U.S. exports were Canada (66%) and Taiwan (32%).

In 2010, imports for consumption of fluorspar increased by about 14% compared with those of 2009 (table 5). The leading suppliers of fluorspar to the United States were Mexico (71%), China (18%), South Africa (6%), and Mongolia (4%).

Compared with those of 2009, imports of HF increased by 18% to 135,000 t (table 6), imports of cryolite (Na_3AlF_6) increased by 88% to 5,320 t (table 7), and imports of AlF_3 more than doubled to nearly 38,000 t (table 8). The majority of HF imports were from Mexico (85%), with Canada (9%) and China (5%) supplying most of the balance. In 2010, almost all AlF_3 imports were from three countries—Mexico (37%), Canada (32%), and China (30%).

World Review

In 2010, world fluorspar production returned to 2008 levels of about 6 Mt, an increase of 8% compared with that of 2009.

Bulgaria.—The Chiprovtzi area in Montana Province has had a long history of mining, but the last mine in the area closed in the 1990s. N&N Group (Italy) began a geologic assessment in 2004 that resulted in expanded knowledge of the extent and quantity of fluorspar resources in the project area. This information encouraged the company to acquire the licenses for the old mines and production plant and to start rehabilitating the mines and constructing a new flotation mill. The new flotation mill and associated equipment was constructed to allow future capacity expansions. In 2009, the mine and flotation plant commenced final industrial tests, and by yearend, all mine- and mill-related obstacles had been resolved. Capacity of the flotation mill was about 2,500 metric tons per month (30,000 t/yr) at the beginning of 2010, with plans to double capacity to maximize mine and mill profitability. The acid-grade fluorspar product was reported to be of high quality; impurities such as arsenic, lead, and phosphates were either not present or found in trace amounts (N&N Group, 2010).

Canada.—Canada Fluorspar Inc. (Markham, Ontario) announced that it received the Federal environmental assessment screening report from the Canadian Government for the company's proposed fluorspar project in St. Lawrence, Newfoundland and Labrador. The report concluded that "the Project is not likely to cause significant adverse environmental effects with the application of the mitigation measures specified in the report." The Federal Government, therefore, has released the project from further environmental assessment. Approvals from the Federal Government closely followed environmental approval from the government of Newfoundland and Labrador. Both paved the way for Canada Fluorspar to pursue its objectives of commencing construction of its mine, mill, tailings facilities, and wharf in the second half of 2011. Fluorspar production was expected to begin in 2013 (Canada Fluorspar Inc., 2010).

China.—China's 2010 fluorspar exports were 598,000 t, more than double those of 2009. Of the total, metspar accounted for 212,000 t and acidspar 386,000 t. Net fluorspar exports were 542,000 t, since China imported 54,000 t of metspar in 2010 (United Nations, 2011).

The Chinese Government issued a new policy concerning hydrogen fluoride called industrial admittance conditions for hydrogen fluoride, which was designed to protect fluorspar resources. The policy focuses on controlling HF capacity through tougher licensing requirements that encourage mergers or acquisitions. HF plants would be required to have a minimum capacity of 50,000 t/yr. The policy encourages existing fluoride companies to acquire fluorspar mine resources and would limit or bar companies without dedicated fluorspar resources from entering or further expanding into the fluoride industry. HF producers would be prohibited from purchasing fluorspar from unlicensed fluorspar companies. The policy is intended to improve integration of the fluoride industry by establishing larger vertically integrated companies producing higher value downstream products. This policy is an adjunct to the previously issued Government policies that limited the total volume of fluorspar produced in the first half of 2010. This reportedly has resulted in a dramatic increase in the domestic market price for fluorspar products (China Shen Zhou Mining & Resources, Inc., 2010).

Kenya.—Kenya Fluorspar Company Ltd. (Nairobi), which mothballed its mine in March 2009 because of low prices and a severe drop in sales, resumed mine production after fluorspar demand increased in the second quarter of 2010. The company's managing director stated earlier in the year that prices would have to exceed $270 per metric ton before the company would consider restarting production (Watts, 2010). Kenya Fluorspar's 2010 production was 44,500 t, which was nearly three times its 2009 output but less than one-half that of 2008.

Maghreb Minerals plc (London, United Kingdom) agreed to acquire Firebird Global Master Fund's 20% shareholding in Kenya Fluorspar in return for 100.3 million Maghreb shares (Seccombe, 2010).

Mexico.—Mexico's second leading fluorspar producer, Fluorita de Mexico S.A. de C.V. (Coahuila) announced that it was in the process of developing new fluorspar mining concessions in the area of its main mine. The new operation would increase Fluorita de Mexico's annual acidspar capacity of 140,000 t by 30,000 to 40,000 t. The company was operating at about 90% of capacity during the early part of 2010. Plans called for the new mine to be in production by the end of 2011 (Industrial Minerals, 2010a). These plans had to be postponed owing to severe flooding and power outages in the northeastern region of the State of Coahuila resulting from hurricane Alex, which came ashore in late June as a category 2 hurricane (Industrial Minerals, 2011).

Mexichem Fluor S.A. de C.V. [a subsidiary of Mexichem S.A. de C.V. (Tlalnepantla)] acquired the fluorochemicals business of the INEOS Group (Lyndhurst, United Kingdom). The deal comprised the international business and assets related to

INEOS' fluorochemical operations in North America, Europe, and Asia. Prior to the Ineos Fluor acquisition, all of Mexichem's primary fluorspar-related businesses were in Mexico. These included fluorspar mines in the State of San Luis Postosi and an HF plant and AlF_3 plant in Matamoros. The acquisition established Mexichem as a major, vertically integrated fluorochemicals company (Mexichem S.A.B. de C.V., 2010).

Mongolia.—Lotus Resources plc (London, United Kingdom), having failed to raise financing to develop its fluorspar projects in Mongolia, sold its Mongolian mining subsidiary (Lotus Minerals Mongolia Ltd.) to Mongolian Minerals Pte. Ltd. Lotus Minerals, through joint-venture partnerships, controlled four fluorspar projects in Mongolia—two exploration licenses (Gat and Dai-Uul) and two mining licenses (Chuluut and Tsagaan Chuluut). All projects were small in scale and were in the country's central eastern region (Eurasia Capital Ltd., 2010).

Mozambique.—Globe Metals and Mining Ltd. (Perth, Australia) performed preliminary drilling on its Mount Muambe fluorspar and rare-earths project. Mount Muambe is a carbonatite crater roughly 6 kilometers (km) in diameter located in the Tete Province of Mozambique. Globe's exploration permit covers the entire crater. To date, results have shown the crater to be mineralized with fluorspar and heavy rare earths, but only a small fraction of the crater has been explored. A total of 16 drill holes were completed for a total of 1,118 meters (m) targeted mostly on the high-grade fluorspar and heavy rare-earths zone in the southwestern part of the carbonatite complex. Results of the preliminary drilling program were due in February 2011 (Globe Metals and Mining Ltd., 2010).

Namibia.—Okorusu Fluorspar (Pty.) Ltd.'s production of acid-grade fluorspar at Okorusu rose to more than 95,000 t in 2010 compared with 73,580 t in 2009. The company, which has always produced acid-grade fluorspar, reported its first sales of metallurgical-grade fluorspar (metspar, 85% CaF_2) to Turkey. As planned, exploration during 2010 focused on the E ore body, which is within the mine's mining license area. Mapping, trenching and sample collecting, and gridding and line cutting were conducted on a 1.5-square-kilometer area. A total of 5,400 m of diamond drilling was completed, with additional drilling planned for 2011. In 2011, the company planned to commission a dense media separation plant (also referred to as heavy-media plant) that would allow the company to upgrade low-grade ores. Okorusu's plans also called for the construction of a new drying plant to improve the metspar business and to begin underground mining of the A ore body (Chamber of Mines of Namibia, 2011).

Norway.—Tertiary Minerals plc (Macclesfield, United Kingdom) acquired fluorspar exploration rights at the former Lassedalen Mine in Norway. The underground mine operated on a small scale during World War II, supplying fluorspar for use in aluminum production. Norsk Hydro A/S dewatered the mine in the late 1970s and carried out a surface and subsurface drilling program. The results of the program were not compliant with any current reserve or resource code. Potentially economic fluorspar mineralization occurs in steeply dipping veins that can be followed more or less continuously on the surface for at least 1 km. The largest veins have a width of 10 to 13 m and extend 200 to 250 m along strike. The company indicated that development of such a high-grade vein deposit would allow production of both metallurgical and acid-grade fluorspar. Future plans included an exploration and metallurgical testing program. Tertiary Minerals' exploration rights extend through the end of 2016 (Tertiary Minerals plc, 2010b).

South Africa.—Maghreb Minerals announced plans to take a controlling interest in South African fluorspar company Sallies Ltd. (Pretoria) in an all-shares deal. Maghreb was expected to purchase the 66.9% stake in Sallies held by Firebird Global Master Funds, giving it a total holding of 78.3%, in return for 335.6 million Maghreb shares. The ownership share would trigger a mandatory offer to minority shareholders. Maghreb raised $10 million in financing in a rights issue and planned to use the funds to restart fluorspar production from Sallies' Witkop Mine. After performing new geologic modeling and revising mining plans, Maghreb intended to produce 125,000 t/yr of acidspar from Witkop for the export market and a small amount of metspar for domestic markets. It was estimated that it would take 3 months to bring Witkop into production once the decision was made to restart operations (Seccombe, 2010). Sallies' Witkop fluorspar was idle most of 2010, but it did sell some stockpiled material into the domestic market for the year ended June 30, 2010, and restarted production in the fall to fill a small order for delivery in October (Prinsloo, 2010).

Sweden.—Tertiary Minerals announced the completion of an independent scoping study on its Storuman fluorspar project in Sweden. A fluorspar mine producing 100,000 t/yr of acid-grade fluorspar, with a mine life of 18 years, was judged feasible. The deposit is low grade, and the study was based on a mine model with a deposit of 18 Mt grading 12.3% CaF_2 that was minable by open pit methods. The current study was based on drilling results from a prior exploration project (1970s) and the 10 holes drilled by Tertiary Minerals in 2008. The company planned additional drilling to define further the ore body and to establish a JORC (Joint Ore Reserves Committee—an Australasian code for reporting exploration results) classified mineral resource (Tertiary Minerals plc, 2010a).

Thailand.—Thailand was a major fluorspar producer and exporter through the 1980s, but production began to decrease during the 1990s owing to Chinese competition. From the late 1990s to 2007, Thailand's fluorspar production was less than 5,000 t/yr. In 2008, production increased to 29,529 t and, in 2009, it increased to 120,340 t. Almost all of this increased production came from the provinces of Lamphun and Mae Hong Son in Thailand's Northern Region. In 2009, reported production from Lamphun Province was 81,670 t and from Mae Hong Son Province 37,750 t. A small amount of additional production came from Kanchanaburi Province in the country's Central Region (Thailand Department of Primary Industries and Mines, undated a). As a result of this increased production, employment in Thailand's fluorspar mining industry has increased to 186 in 2009 from 69 in 2006 (Thailand Department of Primary Industries and Mines, undated b).

Thailand has experienced problems with illegal fluorspar mining, and, in early 2010, the Thailand Department of Special Investigation and border patrol police raided three large-scale illegal mines and confiscated 102,800 t of fluorspar in the Pai district of Mae Hong Son Province (Laohong and Sattha, 2010).

United Kingdom.—After failing to find a buyer or investors, the United Kingdom's sole fluorspar producer, Glebe Mines Ltd. (Derbyshire), reportedly was shutting down at yearend 2010. Glebe Mines was not included in the sale (finalized in March 2010) of its parent, INEOS Fluor, to Mexico's Mexichem Fluor (Industrial Minerals, 2010b). Glebe Mine's primary customer was INEOS Fluor's HF plant at Runcorn in Cheshire, which was part of the sale to Mexichem. Glebe Mines' supply contracts with the Runcorn plant apparently expired at the end of 2010. Glebe Mines remained a part of the INEOS Group, but after the sale of the fluorochemicals business, it was considered a poor fit with the INEOS Group's remaining businesses.

Outlook

The outlook for fluorspar is complicated by world economic concerns over the health of economies in Europe and the United States debt, environmental pressures opposing the use of some fluorochemical products, safety concerns for the use of HF, availability of future fluorspar supplies, and a shift in fluorspar-consuming industries to Asia.

After the worldwide recession, fluorspar markets showed signs of recovery in 2010, especially for metspar, which was driven by the rebound in world steel production (up 17% compared with that of 2009). Demand for acidspar outside of China was slower to recover but began to rise in 2010 and was expected to display continued growth in 2011.

Long-term demand for fluorspar may depend to a large degree on the development and acceptance of fluorine-based replacements for existing fluorocarbon compounds that are likely to be phased out owing to high global warming potentials (GWP). A couple of strong replacement candidates are hydrofluoroolefins HFO-1234yf and HFO-1234ze for use in automotive air-conditioning systems and foam blowing, respectively. These two compounds each have low GWP and rapidly break down in the atmosphere.

Development of new fluorspar mine projects or work on reopening long-idle mines is beginning to pick up after the global economic downturn. With fluorspar exports from China expected to continue to decrease in the long term and major fluorspar-exporting countries looking to follow China's business model of producing higher value downstream fluorochemical products, fluorochemical companies have begun to worry about the future availability of fluorspar on the open market. As a result, fluorochemical companies are starting to acquire fluorspar mines in order to guaranty secure supplies. Solvay S.A. (Brussels, Belgium) was the first company in recent years to secure a source of fluorspar when it acquired Okorusu Fluorspar in Namibia. Several non-Chinese fluorochemical companies have expressed interest in exploring the possibility of acquiring dedicated sources of fluorspar for their needs. This type of vertical integration is being encouraged by the Chinese Government as part of its domestic hydrogen fluoride policy. Vertical integration is not new in the fluorspar business. In the 1970s and earlier, aluminum, fluorochemical, and steel companies owned fluorspar mines outright or were major shareholders in mines in Mexico, South Africa, the United States, and other countries.

Major markets for fluorspar in developed countries have been stagnant or have decreased as first HF and more recently fluorocarbon production has moved to China, and aluminum smelting capacity has moved to countries or regions with access to less expensive energy. This shift is evident in the growing HF and fluorocarbon production capacity in China and the reduced capacities in traditional production areas in Europe, Japan, and North America. China is already the world's leading fluorspar consumer and its share of global consumption will likely continue to increase in the future.

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TABLE 1

SALIENT FLUORSPAR STATISTICS[1, 2]

United States:		2006	2007	2008	2009	2010
Exports:[3]						
Quantity	metric tons	13,000	13,600	18,800	14,100	17,900
Value[4]	thousands	$2,430	$2,650	$3,340	$2,230	$2,740
Imports:[3]						
Quantity	metric tons	553,000	620,000	572,000	475,000	539,000
Value[5]	thousands	$112,000	$111,000	$133,000	$105,000	$103,000
Consumption:						
Reported	metric tons	523,000	539,000	506,000	400,000	448,000
Apparent[6]	do.	608,000 r	613,000	529,000	473,000	502,000
Stocks, December 31:						
Consumer and distributor	do.	89,900 [7]	90,100	115,000	103,000	121,000
Government stockpile	do.	8,110	1,450	--	--	--
World, production	do.	5,660,000	5,730,000 r	6,000,000 r	5,550,000 r	6,010,000

r Revised. do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Does not include fluorosilicic acid production or imports of hydrofluoric acid and cryolite.

[3] Source: U.S. Census Bureau; data may be adjusted by the U.S. Geological Survey.

[4] Free alongside ship values at U.S. ports.

[5] Average unit value for the year, includes cost, insurance, and freight values at U.S. ports. Value data for fluorspar imports appear to be underreported.

[6] Imports minus exports plus adjustments for changes in stocks held by Government and three leading consumers.

[7] Includes fluorspar purchased from the National Defense Stockpile (NDS) but still located at NDS depots.

TABLE 2
U.S. REPORTED CONSUMPTION OF FLUORSPAR, BY END USE[1]

(Metric tons)

End use or product	Containing more than 97% calcium fluoride 2009	Containing more than 97% calcium fluoride 2010	Containing not more than 97% calcium fluoride 2009	Containing not more than 97% calcium fluoride 2010	Total 2009	Total 2010
Hydrofluoric acid and aluminum fluoride	W	W	--	--	W	W
Metallurgical	9,390	10,900	17,900	27,400	27,200	38,300
Other[2]	371,000	410,000	2,030	--	373,000	410,000
Total	380,000	421,000	19,900	27,400	400,000	448,000
Stocks, consumer, December 31	87,200	109,000	15,600	12,400	103,000	121,000

W Withheld to avoid disclosing company proprietary data; included in "Other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] May include cement, enamel, glass and fiberglass, steel castings, welding rod coatings, and hydrofluoric acid.

TABLE 3
PRICES OF IMPORTED FLUORSPAR

(Dollars per metric ton)

Source and grade	2009	2010
Acidspar:		
Chinese, dry basis, cost, insurance, and freight (c.i.f.) Gulf port, filtercake	350–380	360–380
Mexican, free on board (f.o.b.) Tampico, filtercake	260–290	260–290
Mexican, f.o.b. Tampico, arsenic <5 parts per million	300–360	280–320
South African, f.o.b. Durban, filtercake	250–300	290–310
Metspar, Mexican, f.o.b. Tampico	140–195	170–200

Sources: Industrial Minerals, no. 507, December 2009, p. 68; no. 519, December 2010, p. 70.

TABLE 4
U.S. EXPORTS OF FLUORSPAR, BY COUNTRY[1]

Country	2009 Quantity (metric tons)	2009 Value[2]	2010 Quantity (metric tons)	2010 Value[2]
Australia	6	$3,840	135	$19,800
Canada	7,900	1,260,000	11,800	1,820,000
France	--	--	16	4,550
Israel	--	--	29	9,590
Malaysia	6	3,660	28	17,500
Mexico	2,320	394,000	107	27,100
Spain	--	--	32	3,540
Taiwan	3,890	564,000	5,720	829,000
Total	14,100	2,230,000	17,900	2,740,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship values at U.S. ports.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF FLUORSPAR, BY COUNTRY AND CUSTOMS DISTRICT[1]

Country and customs district	2009 Quantity (metric tons)	2009 Value[2] (thousands)	2010 Quantity (metric tons)	2010 Value[2] (thousands)
Containing more than 97% calcium fluoride (CaF_2):				
China:				
Great Falls, MT	319	$38	--	--
Houston, TX	45,100	15,000	89,800	$26,300
Los Angeles, CA	103	13	420	49
New Orleans, LA	21,600	9,210	8,500	2,170
Seattle, WA	234	31	--	--
Total	67,300	24,300	98,700	28,500
Germany, Savannah, GA	--	--	252	32
Mexico:				
Baltimore, MD	536	241	1,550	690
Laredo, TX	42,100	12,900	47,200	12,700
New Orleans, LA	217,000	33,100	239,000	36,600
Total	260,000	46,200	287,000	49,900
Mongolia:				
Houston, TX	28,600	8,590	17,900	5,120
New Orleans, LA	--	--	4,200	1,180
Total	28,600	8,590	22,100	6,300
South Africa:				
Houston, TX	38,800	11,800	33,300	8,300
New Orleans, LA	22,000	7,300	--	--
Total	60,800	19,100	33,300	8,300
United Kingdom:				
Houston, TX	130	17	226	40
Los Angeles, CA	446	52	334	40
Total	576	70	560	79
Grand total	417,000	98,300	442,000	93,100
Containing not more than 97% CaF_2:				
China, Cleveland, OH	--	--	1	3
Mexico:				
Cleveland, OH	1	5	--	--
Laredo, TX	4,430	448	6,240	880
New Orleans, LA	52,900	5,810	90,200	8,810
Total	57,300	6,260	96,500	9,690
Namibia, Houston, TX	203	24	--	--
Grand total	57,500	6,290	96,500	9,690
Grand total, all grades	475,000	105,000	539,000	103,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight values at U.S. ports.

Source: U.S. Census Bureau; data may be adjusted by the U.S. Geological Survey.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF HYDROFLUORIC ACID, BY COUNTRY[1]

Country	2009 Quantity (metric tons)	2009 Value[2] (thousands)	2010 Quantity (metric tons)	2010 Value[2] (thousands)
Belgium	--	--	(3)	$4
Canada	11,000	$39,500	12,000	41,900
China	4,110	4,270	6,520	7,820
Germany	404	1,250	356	1,060
Hong Kong	33	39	55	63
India	120	164	60	78
Japan	559	1,180	892	2,110
Lithuania	(3)	9	--	--
Mexico	97,600	114,000	115,000	145,000
Singapore	64	211	81	264
South Africa	13	22	5	20
Spain	(3)	3	47	80
Switzerland	(3)	2	(3)	3
Taiwan	49	134	209	516
United Kingdom	(3)	3	--	--
Total	114,000	161,000	135,000	199,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight values at U.S. ports.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF CRYOLITE, BY COUNTRY[1]

Country	2009 Quantity (metric tons)	2009 Value[2] (thousands)	2010 Quantity (metric tons)	2010 Value[2] (thousands)
Australia	--	--	2	$13
Canada	5	$14	2	5
China	498	357	1,200	886
Denmark	151	288	--	--
Germany	878	1,330	1,580	2,080
Hungary	250	346	225	261
Italy	--	--	19	25
Japan	860	1,070	1,810	2,350
Mexico	81	30	--	--
United Kingdom	103	195	484	895
Total	2,830	3,630	5,320	6,510

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight values at U.S. ports.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF ALUMINUM FLUORIDE, BY COUNTRY[1]

Country	2009		2010	
	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Canada	6,950	$11,000	12,300	$17,800
China	10,200	14,500	11,400	14,800
Mexico	1,460	1,280	14,100	16,500
Other[3]	45	99 r	74	156
Total	18,700	26,800	38,000	49,200

r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight values at U.S. ports.

[3] Includes Brazil, Germany, Japan, Sweden, Switzerland, and the United Kingdom.

Source: U.S. Census Bureau.

TABLE 9
FLUORSPAR: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country and grade[3, 4]	2006	2007	2008	2009	2010
Argentina	8,278	9,735	15,098	13,424 r	14,000 e
Brazil, marketable:					
Acid grade	41,373	44,869	45,032 r	28,803 r	44,600 e
Metallurgical grade	22,231	20,657 r	18,209 r	15,161 r	19,500 e
Total	63,604	65,526 r	63,241 r	43,964 r	64,100 e
China:e					
Acid grade	1,800,000	1,850,000	1,900,000	1,600,000	1,900,000
Metallurgical grade[5]	1,300,000	1,350,000	1,350,000	1,300,000	1,400,000
Total	3,100,000	3,200,000	3,250,000	2,900,000	3,300,000
Egypt	550 e	11,588 r	9,115 r	4,343 r	5,000
France:e, 6					
Acid and ceramic grades	35,000	--	--	--	--
Metallurgical grade	5,000	--	--	--	--
Total	40,000	--	--	--	--
Germany, acid grade	53,009	54,359	48,519	49,962 r	50,000 e
India:e, 7					
Acid grade	500	1,000	1,500	1,600	1,800
Metallurgical grade	5,800	5,000	5,500	5,600	5,800
Total	6,300	6,000	7,000	7,200	7,600
Iran[8]	65,000	68,192	65,000 e	65,000 e	65,000 e
Italy[6]	8,000	--	--	--	--
Kazakhstan e	30,000	64,000 [9]	66,300	67,000	67,000
Kenya, acid grade	83,428	82,000	98,248	15,667	44,500
Kyrgyzstan e	4,000	4,000	4,000	4,000	4,000
Mexico:[10]					
Acid grade	466,000	513,000 e	591,955 r	640,676 r	640,000 e
Metallurgical grade	470,000	420,000 e	465,694 r	405,264 r	430,000 e
Total	936,000	933,000 e	1,057,649 r	1,050,000 r	1,070,000 e

See footnotes at end of table.

TABLE 9—Continued

FLUORSPAR: WORLD PRODUCTION, BY COUNTRY[1, 2]

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[5] Includes submetallurgical-grade fluorspar used primarily in cement that may account for 33% to 50% of the quantity.

[6] Mine closed in 2006.

[7] Year beginning April 1 of that stated.

[8] Year beginning March 21 of that stated.

Organization.

[9] Reported figure.

[10] Data are reported by Servicio Geológico Mexicano, quantities by grade may be estimated.

[11] Data are reported by Mineral Resource Authority of Mongolia.

[12] Flotation concentrate, including less than 97% CaF_2 material.

[13] Data were in wet tons, but have been converted to dry tons to agree with other data in table.

[14] Data for 2006—09 based on data from the South African Minerals Bureau; data show estimated proportions of acid-grade and metallurgical-grade fluorspar within the reported totals.

[15] USGS inferred estimate based on 2006 to 2009 series.

[16] Data for 2006—09 are reproted by British Geological Survey.

GALLIUM

By Brian W. Jaskula

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant.

In 2010, no domestic production of primary gallium was reported, and imports of gallium metal and gallium arsenide (GaAs) wafer continued to account for most of the U.S. gallium consumption. Metal imports were 65% higher than those in 2009, with the United Kingdom, Germany, China, and Canada, in descending order of imports by gallium content, as the leading sources of imported gallium. Undoped GaAs wafer imports were 123% higher than those in 2009—Canada and the United Kingdom were the principal sources. Doped GaAs wafer imports were 42% higher than those in 2009—Germany and Japan were the principal sources. Almost all gallium consumed in the United States was in the form of GaAs and gallium nitride (GaN) and was used in integrated circuits (ICs) and optoelectronic devices [laser diodes, light-emitting diodes (LEDs), photodetectors, and solar cells]. Gallium consumption increased by 35% from that in 2009. In 2010, gallium consumed in the United States was less than the gallium imported because a large portion of the U.S. imports was estimated to be low-purity material that was refined in the United States and shipped to other countries.

In 2010, estimated world crude gallium production was 182 metric tons (t). Principal producers were China, Germany, Kazakhstan, the Republic of Korea, Russia, and Ukraine. Plants in Hungary and Japan also recovered gallium. Refined gallium production was estimated to be about 268 t, which may inadvertently include some refined new scrap. Refined gallium was produced in China, Japan, the United Kingdom, and the United States.

Legislation and Government Programs

In an effort to help the United States develop larger, more cost effective GaN substrates used in high-performance electronic device applications, the U.S. Department of Defense awarded Kyma Technologies Inc. (Raleigh, NC) $2.8 million. In addition to the defense GaN device applications, the funding was expected to help the United States compete with China, Japan, and the Republic of Korea in commercial GaN device applications (Wang, 2010).

In November, TriQuint Semiconductor, Inc. (Hillsboro, OR) was awarded a $17.4 million Defense Production Act Title III GaN manufacturing development contract by the U.S. Air Force Research Laboratory. The overall goal of the contract was to increase yield, lower costs, and improve time-to-market cycles for defense and commercial applications of GaN integrated circuits (TriQuint Semiconductor, Inc., 2010).

The U.S. Department of Energy (DOE) awarded $13.4 million to four GaN research projects focused on accelerating development in power electronics. The award recipients included HRL Laboratories LLC, Massachusetts Institute of Technology, Transphorm Inc., and Virginia Technology (Compound Semiconductor, 2010a).

Production

No domestic production of primary gallium was reported in 2010 (table 1). Recapture Metals Ltd. [a subsidiary of Neo Material Technologies, Inc. (Toronto, Ontario, Canada)] recovered gallium from scrap materials, predominantly those generated during the production of GaAs. Recapture Metals' facilities have the capability to produce about 50 metric tons per year of high-purity gallium. The company recovered gallium from its customers' scrap on a fee basis and purchased scrap and low-purity gallium for processing into high-purity material.

Consumption

Gallium consumption data were collected by the U.S. Geological Survey from a voluntary survey of U.S. operations. In 2010, there were 12 respondents to the gallium consumption survey, representing 71% of the total canvassed. Data in tables 2 and 3 were adjusted by incorporating estimates to reflect full industry coverage. Many of these estimates were based on company 2010 10–K reports submitted to the U.S. Securities and Exchange Commission.

More than 97% of the gallium consumed in the United States was in the form of GaAs or GaN. GaAs was used to manufacture optoelectronic devices (laser diodes, LEDs, photodetectors, and solar cells) and ICs. ICs accounted for 69% of domestic consumption, optoelectronic devices accounted for 30%, and 1% was used in research and development and other applications (table 2). GaN principally was used to manufacture LEDs and laser diodes.

In 2010, U.S. consumption of gallium for use in ICs increased by 26% from that of 2009 owing to the strong growth of GaAs-rich "smartphones" (cellular telephones with advanced personal computer-like functionality) and other wireless communication devices, along with continued growth in the aerospace and defense markets. Gallium use in LEDs and laser diodes increased by 75% from that of 2009 owing to the exceptional growth in demand from the LED industry, which began in the second half of 2009 and continued throughout 2010. Gallium suppliers to the photodetector and solar cell industry, however, were negatively affected in 2010 by a combination of the worldwide economic downturn, copper-indium-gallium selenide (CIGS) manufacturing issues, and the rapidly decreasing prices of silicon-based solar cells. U.S. gallium consumption in photodetectors and solar cells decreased by 28% compared with that of 2009.

Gallium Arsenide.—The value of worldwide GaAs device consumption increased to $4.9 billion in 2010, a 32% increase from $3.7 billion in 2009. The rapid adoption of sophisticated third-generation (3G) and fourth-generation (4G) smartphones accelerated demand for GaAs power amplifiers.

Fourth-generation smartphones use up to six times the amount of GaAs that a standard cellular telephone does. In 2010, smartphone market sales increased by 66% compared with a 16% increase in 2009. GaAs was also consumed in LED applications, supplying approximately 35% of the LED market, with GaN still being the primary LED technology (Compound Semiconductor, 2010b; Semiconductor Today, 2011d, f).

To meet growing GaAs power amplifier demand, WIN Semiconductors Corp. (Taiwan, China) announced plans to increase its 6-inch GaAs wafer production capacity to 20,000 wafers per month by yearend 2011, an increase of approximately 40% from that of 2010 (Semiconductor Today, 2010c).

Gallium Nitride.—Increased demand for GaN device applications, namely laser diodes, power electronics, and radio-frequency (RF) electronics, provided significant growth opportunities for advanced GaN-based products. GaN power management applications, in particular, have shown much promise. GaN power transistors operate at higher voltages and with a higher power density than current GaAs devices. GaN power transistors and amplifiers have enabled microwave designers to reduce heat sink requirements and part counts, leading to smaller systems with higher performance and greater efficiency. The key drivers of this emerging GaN-based technology have been military and defense applications, but the technology also was being driven by automotive, industrial, medical, and other consumer applications.

The value of worldwide GaN LED consumption increased to $8.4 billion in 2010, a 75% increase from $4.8 billion in 2009. LED-backlit televisions were the leading end use for GaN LEDs (Manners, 2011).

In November, Sumitomo Electric Industries Ltd. (Tokyo, Japan) announced that it had developed the world's first 6-inch diameter GaN substrates to be used for white LEDs. Sumitomo planned to bring the 6-inch substrate into large-scale production and expected the material to be used in white LEDs and power devices (Semiconductor Today, 2010b).

Light-Emitting Diodes.—The worldwide high-brightness (HB) LED market increased to $10.8 billion in 2010, a 93% increase from $5.6 billion in 2009. HB-LEDs experienced record growth as a result of the rapid shift to LEDs in mobile display applications and liquid crystal display (LCD) monitors and televisions using LED-based backlighting. LED-based backlighting allows for lighter and thinner screens, higher color saturation, and lower power consumption compared with traditional cold-cathode fluorescent lamp backlighting sources. Research and consulting firm Strategies Unlimited estimated that the television and monitor LED-based backlighting segment increased by approximately a factor of 10 compared with that in 2009, to reach 33% of the overall HB-LED market in 2010. Mobile display applications (such as cellular telephones, computer notebooks and tablets, eBooks, MP3 players) were the largest HB-LED market segment in 2010, with a 39% share—doubling in size from the 2009 share. Other HB-LED market segments in 2010 included automotive, general lighting, and signage, with respective market shares of 8%, 8%, and 6% (Whitaker, 2011a).

Japan and the Republic of Korea supplied 33% and 28%, respectively, of the 2010 worldwide HB-LED market. Additionally, the United States and Europe supplied 23% of the market, Taiwan supplied 14%, and China supplied 2%. China's HB-LED market share was expected to increase greatly by 2015 owing to the large investments it was making in its domestic solid state lighting industry (Whitaker, 2011a).

LED firms continued expanding their manufacturing capacities in 2010 in response to the growing popularity of LED backlighting and mobile display applications. Semiconductor Equipment and Materials International (SEMI) of San Jose, CA, indicated that 19 new LED fabrication plants came online worldwide in 2010. Investment in LED fabrication plants increased to $1.78 billion in 2010, a 194% increase from $606 million in 2009. SEMI announced that the regions with the largest investments in LED fabrication plants were Taiwan ($593 million), followed by the Republic of Korea ($482 million), and China ($467 million) (Tseng, 2011).

Boosted by the rapidly growing HB-LED market, more than 780 metal-organic chemical vapor deposition (MOCVD) reactors were shipped during 2010. The MOCVD reactors were used to make GaN LEDs. Aixtron AG (Herzogenrath, Germany) and Veeco Instruments Inc. (Plainview, NY) were the leading MOCVD manufacturers (Compound Semiconductor, 2011b).

As HB-LED demand increased throughout 2010, materials suppliers began adding more capacity for trimethylgallium (TMG), a metal-organic chemical used in the fabrication of epiwafers. When TMG and nitrogen gas are fed into the MOCVD reactor and heated, a GaN layer is formed on the epiwafer. TMG's purity and quality determine an LED's brightness and reliability (Seok-hyeon, 2010). In the United States, AkzoNobel N.V. (Amersfoort, Netherlands) increased TMG production capacity at its plant in Texas, and Dow Electronic Materials (Philadelphia, PA) announced it would expand TMG production capacity at its plant in Massachusetts. Albermarle Corp. (Baton Rouge, LA), Chemtura Organometallics GmbH/UP Chemical Co., Ltd. (Bergkamen, Germany and Republic of Korea), and Dow Electronic announced they would build TMG production facilities in the Republic of Korea. Lake LED Materials (Daejon, Republic of Korea) and ATMI Inc. (Danbury, CT) completed construction of a TMG plant in South Chungcheong Province. SAFC Hitech (St. Louis, MO) announced it would expand TMG production capacity at its plant in Bromborough, United Kingdom (Whitaker, 2011b).

Solar Cells.—Sustained high energy prices continued to spark interest in solar energy. In 2010, the solar cell market continued to be dominated by crystalline silicon solar cells, which account for approximately 90% of the market. However, a lightweight, flexible, durable, and low-cost thin-film photovoltaic technology—CIGS—has entered the printed solar cell market. CIGS modules can be directly integrated into building materials, consumer electronics for portable power, space applications, or configured as stand-alone modules for large-scale terrestrial deployment. Industry experts thought CIGS would eventually be able to compete with conventional silicon-based photovoltaic technology. CIGS technology, however, has been slow to enter the commercial market owing to a decline in prices of silicon-based solar cells, the continued global economic downturn affecting the photovoltaic industry, and a complicated manufacturing process that has impeded commercial mass production of CIGS panels.

Several records for CIGS efficiency were achieved in 2010. In August, scientists at the Center for Solar Energy and Hydrogen Research, ZSW in Stuttgart, Germany, achieved a record 20.3% efficiency for their CIGS solar cell in a laboratory setting. The Fraunhofer Institute for Solar Energy Systems in Freiburg, Germany, confirmed the new results (Compound Semiconductor, 2010c). In December, MiaSolé (Santa Clara, CA) achieved a record 15.7% efficiency for its commercial-scale CIGS solar cell. The results were confirmed by the DOE's National Renewable Energy Laboratory (Cartledge, 2010).

SoloPower Inc. (San Jose, CA) announced it would build a high-volume CIGS manufacturing facility in Wilsonville, OR, with a production capacity of 300 megawatts (MW). In August, AQT Solar (Sunnyvale, CA) opened a CIGS manufacturing facility in Sunnyvale, CA, with an initial production capacity of 15 MW. The company also announced it would build a CIGS manufacturing facility in Blythewood, SC, with an initial production capacity of 40 MW. AQT expected the production capacity of the Blythewood facility to increase to 1 gigawatt by the end of 2014 (Semiconductor Today, 2011a, c).

Researchers at the University of Illinois developed an efficient, lower cost method of manufacturing photovoltaic GaAs compound semiconductors that also allows versatility in the types of devices into which they could be incorporated. The manufacturing method allows creation of bulk quantities of flexible GaAs-based solar cells that can be incorporated onto surface areas much larger than conventional solar panels (Brumfiel, 2010).

Prices

Since 2002, producer prices for gallium have not been quoted in trade journals. Data in table 4 represent the average customs value of gallium imported into the United States. Reports in Metal-Pages indicated that low-grade gallium prices increased significantly in 2010. At the beginning of the year, the low-grade gallium price was reported to be about $395 per kilogram. By August, the price had increased to about $595 per kilogram. By December, the price had increased to about $635 per kilogram.

From U.S. Census Bureau import data, the annual average value for low-grade (99.99%-pure) gallium was estimated to be $307 per kilogram, about the same as the estimated average value for 2009. For high-grade (>99.99%-pure) gallium, the annual average estimated value increased to $600 per kilogram, about 34% higher than that in 2009. Import data reported by the U.S. Census Bureau do not specify purity, so the values listed in table 4 were estimated based on the average value of the material imported and the country of origin.

Foreign Trade

In 2010, U.S. gallium imports were 65% higher than those in 2009 (table 5). The United Kingdom (35%), Germany (24%), China (21%), and Canada (7%) were the leading sources of imported gallium.

In addition to gallium metal, GaAs wafers were imported into the United States (table 6). In 2010, 63,200 kilograms (kg) of undoped GaAs wafers and 166,000 kg of doped GaAs wafers were imported. Imports of undoped GaAs wafers were 123% higher than those in 2009, while imports of doped GaAs wafers were 42% higher than those in 2009. The large volumes of undoped GaAs wafers were primarily imported from Canada and the United Kingdom. The large increase was most likely owing to intercompany transfers between foreign and U.S. subsidiaries of the same company. The data listed in table 6 may include some packaging material and, as a result, quantities may be higher than the actual total weight of imported wafers.

World Review

Imports of gallium into Japan and the United States, the two leading consuming countries, were used as the basis for estimating world gallium production. In addition, Roskill Information Services Ltd. provided updated Chinese gallium production estimates, expanding China's production considerably owing to the contributions from newer Chinese gallium operations. Estimated worldwide crude gallium production was 182 t in 2010. Principal world producers were China, Germany, Kazakhstan, the Republic of Korea, Russia, and Ukraine. Gallium also was recovered in Hungary and Japan. Refined gallium production was estimated to be about 235 t, which may inadvertently include some new scrap refining. To avoid double counting previously produced gallium, the refined gallium production figure attempts to eliminate recycled new scrap. China, Japan, the United Kingdom, and the United States refined gallium.

Neo Material Technologies and Roskill Information Services estimated worldwide gallium consumption at 280 t in 2010. Neo Material also estimated that 50% of gallium consumed worldwide in 2010 came from recycled sources (Roskill Information Services Ltd., 2011, p. 47; Seeley, 2011). Gallium was recycled from new scrap in Canada, Germany, Japan, the United Kingdom, and the United States.

China.—In 2010, China's LED industry increased by 34% in value from that of 2009 owing to the rapid growth of the HB-LED backlighting, mobile display applications, and general lighting markets. China installed nearly 300 MOCVD reactors in 2010, which resulted in a 78% increase in value of its LED epitaxy sector from that of 2009; the country was expected to account for a significant share of the MOCVD market in upcoming years. Significant incentives were established by the Chinese Government to build a dominant LED industry. The Chinese Government also implemented a widespread street-lighting program that was expected to create strong domestic demand for LED-based lighting (Semiconductor Today, 2011b; Young, 2011).

China's primary gallium producers were Aluminum Corporation of China, Ltd.; Beijing JiYa Semiconductor Material Co., Ltd.; China Crystal Technologies, Ltd.; East Hope Mianchi Gallium Industry, Co.; and Zhuhai Fangyuan. China's total primary gallium production capacity in 2010 was estimated to be 141 t. Capacity was expected to increase in 2011 (Roskill Information Services, Ltd., 2011, p. 13–15, 21–26).

Japan.—The Japan Oil, Gas, and Metals National Corp. (JOGMEC) estimated that Japan consumed 116 t of gallium in 2010, with the LED market accounting for 43% of consumption

(Kita Yoshiyuki, director Rare Metals Stockpile Department, Japan Oil, Gas, and Metals National Corp., written commun., February 23, 2011).

Outlook

According to IQE plc, smartphones represented a fundamental structural shift in mobile communications. Increased use of smartphones, which on the average contain 480% more GaAs-rich RF content than standard cellular telephones, was expected to account for 28% of all handset sales in 2011, increasing to 50% by 2016. Installation of 3G and 4G mobile networks in India and the Republic of Korea was expected to increase sales of smartphones further. Additional increases in GaAs demand will also result from new applications for wireless fidelity (WiFi), such as point-to-point communications, smart meters, and tablet personal computer technologies. Strategy Analytics predicted that GaAs industry sales would increase at a compound annual growth rate of 5%, increasing to $4.7 billion by 2014 (IQE plc, 2010; Semiconductor Today, 2011g).

Research and consulting firm iSuppli Corp. predicted the GaN power management market would reach $184 million in revenue by 2013. The firm indicated that two events—silicon attaining its practical limits in power management semiconductors and technologic breakthroughs in growing GaN layers on silicon—favored GaN power management devices taking market share away from conventional metal oxide semiconductor field-effect transistors, driver ICs, and voltage regulator ICs. The GaN power management devices' improved efficiency and smaller size would be in high demand for portable electronic products as well as for power-hungry enterprise servers and wired communications infrastructure equipment (Shaw, 2010). GaN power management devices accounted for 3.5% of the global semiconductor market in 2010 (Compound Semiconductor, 2011a).

Strategy Analytics indicated that the U.S. defense industry would continue to be the major customer influencing the RF and power management GaN microelectronics market. The firm expected military applications to represent nearly one-half of the market by 2014 (Semiconductor Today, 2010a).

According to market research firm TrendForce, the HB-LED market was forecast to increase by 8% in 2011 owing to weak demand in the LED backlighting market and lowered LED selling prices, which would result in an oversupply in the LED market. A main factor for the weak demand was the advance in LED technology that allowed reduction in the number of LED units required for television backlighting. Significant LED capacity expansions in 2011 were expected to put further pressure on prices (Semiconductor Today, 2011e).

IMS Research forecast that 833 MOCVD reactors would be shipped worldwide in 2011, a 4% increase from that of 2010. Approximately 570 MOCVD reactors were expected to be shipped in 2012 (Compound Semiconductor, 2011c).

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TABLE 1

SALIENT U.S. GALLIUM STATISTICS[1]

(Kilograms unless otherwise specified)

		2006	2007	2008	2009	2010
Production		--	--	--	--	--
Imports for consumption		26,900	37,100	41,100	35,900	59,200
Consumption		20,300	25,100	28,700	24,900	33,500
Price[2]	dollars per kilogram	443	530	579	449	600

-- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Estimate based on average value of U.S. imports of high-purity gallium.

TABLE 2

U.S. CONSUMPTION OF GALLIUM, BY END USE[1, 2]

(Kilograms)

End use	2009	2010
Optoelectronic devices:		
Laser diodes and light-emitting diodes	5,370	9,390
Photodetectors and solar cells	849	612
Integrated circuits:		
Analog	17,200	21,200
Digital	1,280	2,100
Research and development	135	235
Other	68	--
Total	24,900	33,500

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes gallium metal and gallium compounds.

TABLE 3
STOCKS, RECEIPTS, AND CONSUMPTION OF GALLIUM, BY GRADE[1, 2]

(Kilograms)

Purity	Beginning stocks	Receipts	Consumption	Ending stocks
2009:				
99.99% to 99.999%	2,710	528	--	3,240
99.9999%	929	927	1,120	740
99.99999% to 99.999999%	173	383	438	118
Total	3,820	1,840	1,550	4,100
2010:				
99.99% to 99.999%	3,240	624	--	3,870
99.9999%	740	500	280	960
99.99999% to 99.999999%	118	501	475	144
Total	4,100	1,630	755	4,970

-- Zero.

[1] Consumers only.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4
ESTIMATED AVERAGE GALLIUM PRICES

(Dollars per kilogram)

Gallium metal	2009	2010
Purity ≥ 99.9999%; average value of U.S. imports	449	600
Purity ≤ 99.99%; average value of U.S. imports	304	307

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF GALLIUM (UNWROUGHT, WASTE, AND SCRAP), BY COUNTRY[1]

Country	2009		2010	
	Quantity (kilograms)	Value[2]	Quantity (kilograms)	Value[2]
Canada	10,500	$3,670,000	4,170	$1,480,000
China	6,100	2,240,000	12,200	3,960,000
France	719	325,000	601	378,000
Germany	7,110	2,630,000	14,400	3,760,000
Japan	915	504,000	649	409,000
Netherlands	20	9,000	1,400	745,000
Norway	62	26,200	--	--
Russia	--	--	1,000	395,000
Singapore	--	--	530	218,000
Slovakia	--	--	3	3,540
Taiwan	24	3,480	--	--
Ukraine	3,750	990,000	3,810	1,360,000
United Kingdom	6,740	2,170,000	20,500	6,450,000
Other	-- r	-- r	--	--
Total	35,900	12,600,000	59,200	19,200,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF GALLIUM ARSENIDE WAFERS, BY COUNTRY[1]

Material and country	2009 Quantity (kilograms)	2009 Value[2]	2010 Quantity (kilograms)	2010 Value[2]
Undoped:				
Austria	30	$16,000	34	$22,500
Canada	15,800	2,480,000	19,500	1,720,000
Germany	--	--	103	12,700
India	--	--	9,030	12,000
Japan	72	3,600	1	5,400
Singapore	--	--	100	24,200
Taiwan	886	173,000	2,140	128,000
United Kingdom	11,500	21,900	32,200	55,700
Other	13	24,200	9	14,100
Total	28,300	2,720,000	63,200	1,990,000
Doped:				
China	5,680	10,200,000	14,100	21,200,000
Czech Republic	309	236,000	1,460	1,350,000
Finland	1,370	1,410,000	4,180	2,440,000
France	1,630	4,290,000	7,050	7,220,000
Germany	29,500	18,200,000	30,500	25,700,000
Italy	6,120	196,000	193	126,000
Japan	52,800	57,000,000	72,100	84,800,000
Korea, Republic of	2,610	946,000	1,100	787,000
Poland	473	205,000	1,230	691,000
Singapore	6,430	10,100,000	8,800	12,900,000
Taiwan	7,560	22,000,000	20,300	28,500,000
United Kingdom	1,160	2,280,000	2,950	1,750,000
Other	1,350 r	1,390,000 r	2,010	1,740,000
Total	117,000	129,000,000	166,000	189,000,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

Source: U.S. Census Bureau.

TABLE 7
ESTIMATED WORLD ANNUAL PRIMARY GALLIUM PRODUCTION CAPACITY, DECEMBER 31, 2010[1]

(Metric tons)

Country	Capacity
China	141
Germany	35
Hungary	8
Japan	10
Kazakhstan	25
Korea, Republic of	16
Russia	10
Ukraine	15
Total	260

[1] Includes capacity at operating plants as well as at plants on standby basis.

GARNET, INDUSTRIAL

By Donald W. Olson

Domestic survey data and table were prepared by Connie Lopez, statistical assistant.

In 2010, U.S. production of crude garnet concentrate for industrial use was estimated to be 52,600 metric tons (t) valued at about $7.91 million (table 1). U.S. imports and exports of industrial garnet were estimated to be 42,500 t and 11,700 t, respectively. U.S. apparent consumption was estimated to be 83,500 t.

This report includes information on garnet produced in the United States that was used for industrial purposes. Current information on gem-grade garnet can be found in the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals, chapter on gemstones. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data.

The name "garnet" comes from either the Middle English word "gernet," meaning dark red, or the Latin word "granatus," meaning grain, possibly a reference to the pomegranate (Punica granatum), a fruit plant with red seeds similar in shape, size, and color to some garnet crystals. Garnet has been used as a gemstone for centuries. Garnet necklaces have been found in burial sites as far back as the Bronze Age, and garnet is found among the ornaments adorning the oldest Egyptian mummies. Garnet also is ideal for many industrial applications because of its angular fractures, relatively high hardness and specific gravity, chemical inertness, nontoxicity, lack of crystalline silica, and its ability to be recycled.

Garnet is the general name given to a group of complex silicate minerals, all with isometric crystal structure and similar properties and chemical composition. The general chemical formula for the garnet minerals is $A_3B_2(SiO_4)_3$, where A can be calcium, ferrous iron, magnesium, or manganese, and B can be aluminum, chromium, ferric iron, or rarely, titanium. The most common garnet minerals are classified into three groups—the aluminum-garnet group, the chromium-garnet group, and the iron-garnet group. The most common minerals of the aluminum-garnet group are almandine or almandite, grossularite, pyrope, and spessartite.

Andradite is the most common iron-garnet mineral, and uvarovite is the most common chromium garnet. Garnet occurs worldwide in many rock types, principally gneisses and schists; other sources include contact metamorphic rocks, metamorphosed crystalline limestones, pegmatites, and serpentinites. Alluvial garnet is associated with heavy-mineral sand and gravel deposits in many parts of the world. Occurrences of garnet are numerous; however, relatively few commercially viable garnet deposits have been discovered.

Production

The U.S. industrial garnet industry is dominated by a few major producers. The garnet industry has encountered progressively higher production costs and tighter profit margins since the mid-1990s. These factors have resulted in the loss of noncompetitive producers. Because of the need to keep production costs at a minimum, the most competitive producers are those who produce garnet in combination with one or two other minerals, have reserves that can be mined at a low cost, and have the ability to react rapidly to changes in market demand. The value of industrial garnet is influenced by the size and grade of reserves, the type and quality of garnet mined, the proximity of deposits to infrastructure and consumers, and the milling costs. Pricing within the U.S. garnet industry is very competitive, and suppliers must provide a high level of customer service. The majority of industrial-grade garnet mined in the United States is almandine (iron aluminum silicate) and pyrope (magnesium aluminum silicate); some andradite (calcium iron silicate) also is mined domestically. Industrial garnet is produced from alluvial bar and beach deposits, like those in Idaho and Montana (also those in Australia and India), and it is produced from hard rock deposits, like those in New York (Moore, 2006).

Four U.S. companies accounted for all domestic production—one in Idaho, one in Montana, and two in New York. The USGS obtained the data in this report through a survey of U.S. industrial garnet producers. Two of the four domestic producers reported their output and sales to the USGS, and production amounts and values for the nonreporting companies were estimated.

In 2010, U.S. production of crude garnet concentrate for industrial use was estimated to be 52,600 t valued at about $7.91 million (table 1). This was a 15% increase in production and an increase of 15% in value compared with 45,600 t valued at $6.85 million in 2009. The United States accounted for about 4% of global industrial garnet production. Refined garnet material sold or used during 2010 was 28,900 t valued at $7.43 million, a unit value of $257 per ton, which was a 31% increase in quantity, an increase of about 22% in value, and a 7% decrease in unit value compared with the 2009 levels. Garnet producers in 2010 were Barton Mines Co., LLC in Warren County, NY; Emerald Creek Garnet Ltd. in Benewah County, ID; NYCO Minerals, Inc. in Essex County, NY; and Ruby Valley Garnet LLC in Madison County, MT. In addition to the producers cited above, International Garnet Abrasive Inc. in Clinton County, NY, processed and sold all the garnet mined by NYCO Minerals as a byproduct of wollastonite production in 2010.

Consumption

In 2010, the estimated U.S. apparent consumption of industrial garnet was 83,500 t. The United States accounted for about 6% of global industrial garnet use.

The end uses for garnet in the United States and their estimated market share in 2010 were abrasive grains for waterjet cutting, 35%; abrasive blasting media, 30%; water filtration, 20%; abrasive powders, 10%; and other, 5%. Domestic industries that consume garnet include aircraft and motor vehicle manufacturers, ceramics and glass producers, electronic component manufacturers, filtration plants, glass polishing, the petroleum industry, shipbuilders, textile stonewashing, and wood-furniture-finishing operations.

Most industrial garnet is used as an abrasive because of its hardness, which ranges from 6 to 7.5 on the Mohs scale. High-quality, high-value garnet grain has been used principally for such applications as optical lens grinding and plate-glass grinding for more than a century; industrial diamond and fused aluminum oxide are competitors in these applications. In recent years, industrial garnet powders have been used for high-quality, scratch-free lapping of semiconductor materials and other metals. Garnet has replaced some silica sand in the abrasive blasting media market because garnet does not have the health risks associated with the inhalation of airborne crystalline silica dust. At present, however, silica sand and mineral slag continue to be the most widely used media in blasting. The U.S. petroleum industry is one of the leading garnet-consuming industries, using garnet for cleaning drill pipes and well casings. The aluminum aircraft manufacturing and shipbuilding industries use garnet for blast cleaning and for finishing metal surfaces. Similar uses include the cleaning and conditioning of aluminum and other soft metals, as well as metal cleaning by structural steel fabrication shops. Garnet entrained in high-pressure streams of water also is used to cut many different materials. Garnet powders generally are used for antiskid surfaces, antislip paints, and glass and ceramic polishes.

Waterjet cutting is the process of combining water under ultrahigh pressure with entrained garnet grains to cut a wide variety of materials. Materials cut using this process range from soft leather and fabric to hard steel, titanium, and other metals. Waterjet cutting makes it possible to carve extremely complex shapes with computer-assisted cutter control. Water is first focused into a narrow, restricted stream (usually about 0.25 millimeter in diameter) by passing it through a ruby or diamond orifice. The water stream then passes through a mixing chamber and focusing tube. Garnet is introduced in the mixing chamber, where it begins to mix with the water stream and continues mixing in the focusing tube. The garnet-water mixture exits the tube at very high velocity and is directed at the item to be cut. Almandine-pyrope garnet is excellent for this application as it strikes the necessary balance between cutting productivity and equipment wear. The waterjet market began to develop slowly in the late 1980s and early 1990s, and it has increased at a faster rate in the past 20 years. Future growth is expected to remain steady as use of this technology expands in existing areas and enters new applications that require an entrained flow of abrasive garnet in a water stream to cut metal, plastics, and glass. Abrasive waterjet cutting provides a tool for manufacturers faced with the task of cutting new materials, such as composites and sandwiched materials that had been problematic to machine in the past. Waterjet cutting allows for flexibility and eliminates the need for flame cutting. Cutting fragile materials or intricate patterns in a work piece by abrasive waterjet cutting significantly decreases the amount of distortion or breakage (Rapple, 2006).

Low-quality industrial garnet, which has lower hardness and is more highly fractured, is used as a high-density medium in water filtration systems because of its relative inertness and resistance to chemical degradation. Garnet is well suited for water filtration and treatment because it is relatively heavy and chemically stable. Mixed-media water filtration, which uses a mixture of anthracite, garnet, and silica sand, has displaced older filtration methods because it provides better water quality. Garnet competes with ilmenite, magnetite, plastics, and silica sand as a filtration medium.

Other applications for garnet include the manufacture of coated abrasives and the finishing of felt, hard rubber, leather, plastics, and wood. In the coated-abrasive market, garnet falls between low-cost quartz sand or staurolite and more costly manufactured abrasives, such as fused alumina and silicon carbide. Garnet is more efficient than quartz sand in most coated-abrasive applications. Owing to its friable nature and lower hardness, garnet cannot compete with manufactured abrasives in metalworking applications that require substantial metal removal.

Prices

Industrial garnet is priced at a wide range, depending on application, quality, quantity purchased, source, and type. During 2010, domestic values for crude concentrates for different applications ranged from about \$83 to \$226 per metric ton, with an average for the year of \$150 per ton. Domestic values for refined garnet for different applications sold during the year ranged from \$83 to \$287 per ton, with an average for the year of \$257 per ton.

The estimated average values of garnet from other leading producers around the world based on the value of import shipments are as follows: Australia, \$344 per ton; Canada, \$304 per ton; China, \$384 per ton; and India, \$182 per ton. During 2010, the average value of industrial garnet imported from all sources was \$261 per ton, which was a 12% increase from \$234 per ton in 2009.

Foreign Trade

Lower priced foreign imports of garnet slowly began displacing U.S. production in domestic markets during the 1990s. For the past 6 years, industrial garnet imports have provided between 44% and 60% of the U.S. total industrial garnet supply.

The U.S. Census Bureau compiles trade data on exports and imports of industrial garnet mixed with other natural abrasive commodities, such as emery and corundum, so the data cannot be identified specifically as garnet. Based on reports from some producers and other industry sources, exports and imports of industrial garnet were estimated to be 11,700 t and 42,500 t, respectively, in 2010. Exports decreased by about 11% from those of 2009, and imports increased by about 12% compared with those of 2009. In 2010, Australia, Canada, China, and India continued to supply the majority of the U.S. garnet imports, with

India providing 56%; Australia, 23%; China, 17%; Canada, 2%; and other countries, 2% of industrial garnet imported into the United States for consumption. Garnet exported by the United States was shipped to Asian, Canadian, Caribbean, Central American, European, and South American markets. About 63% of garnet exports from the United States went to Brazil, Canada, China, Germany, Mexico, and Taiwan.

During 2010, GMA Garnet Corp., based in Western Australia, took a 5-year lease on a port facility in Fairless Hills, PA. The facility is located on a former U.S. Steel mill site along the Delaware River and is accessible to major highways, rail lines, and a deepwater port. GMA will use the facility to establish a Northeastern United States location to receive 10,000-ton parcels of Australian garnet in loose bulk for storage. From there, GMA will test the quality of the garnet and package it for distribution throughout North America. GMA also intends to construct a large-scale garnet recycling plant at the facility in Fairless Hills, PA (NAI Global, 2010).

World Review

The USGS estimated total world industrial garnet production to be about 1.41 million metric tons. In 2010, India, China, Australia, and the United States were, in decreasing tonnage order, the leading producers. In 2010, India produced about 50% of total global production; China, about 33%; Australia, 11%; the United States, about 4%; and other countries, about 2%. China and India are expected to continue as leading world producers of industrial garnet. Russia and Turkey have been mining garnet in recent years, primarily for domestic markets. Small garnet-mining operations also are located in Canada, Chile, the Czech Republic, Pakistan, South Africa, Spain, Thailand, and Ukraine. Production in most of these countries is for domestic use.

Australian industrial garnet production and exports increased from 1998 until 2006, and have remained approximately the same each year since. In 2010, Australian industrial garnet production and exports decreased by about 6% from those of the previous year. China and India also have steadily increased garnet output in the past decade and have become significant garnet sources for other countries. Worldwide end uses and their estimated market shares are abrasive blasting media, 50%; abrasive grains for waterjet cutting, 30%; water filtration, 15%; and other end uses, 5%.

Outlook

The U.S. garnet industry has encountered higher production costs and tighter profit margins during recent years. The industry has also been competing with lower priced foreign imports that have displaced U.S. production in domestic markets, so much so that, for 2 of the past 6 years, industrial garnet imports have exceeded domestic industrial garnet production. This has resulted in the closure of noncompetitive operations. Because of the need to keep production costs at a minimum, the most competitive producers are those who produce garnet in combination with one or two other minerals, have reserves that can be mined at a low cost, and have the ability to react rapidly to changes in market demand. An example of a new mining operation that will produce more than one mineral is the mine being developed in Coos County, OR, by Oregon Resources Corp. The mine was expected to begin production during May 2011 and be in full operation by yearend 2011. Oregon Resources estimated that the mine will produce 635,000 t of ore per year, yielding 54,400 t of chromite and 16,300 to 18,100 t of spessartite garnet each year. The garnet is intended for waterjet cutting markets. Zircon will also be produced. Oregon Resources projected a 15-year mine life for the operation (James Dingman, director of marketing and sales, Oregon Resources Corp., written commun., February 28, 2007; oral commun., December 17, 2010, and May 5, 2011).

Worldwide demand for industrial garnet is expected to continue, especially within the markets for abrasive grains for waterjet cutting and for abrasive blasting media. Garnet demand also is expected to continue for aircraft manufacturing and shipbuilding, where significant quantities of garnet are used for abrasive blast cleaning and finishing of metal surfaces and for waterjet cutting. The use of garnet in waterjet cutting is expected to increase at a higher rate than the use of garnet as an abrasive blasting media.

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TABLE 1
ESTIMATED SALIENT U.S. INDUSTRIAL GARNET STATISTICS [1]

		2006	2007	2008	2009	2010
United States:						
Crude production:						
Quantity	metric tons	34,100	61,400	62,900	45,600	52,600
Value	thousands	$4,240	$11,300	$13,600	$6,850	$7,910
Sold or used:[2]						
Quantity	metric tons	16,800	20,700	49,800	22,100	28,900
Value	thousands	$5,330	$5,830	$13,500	$6,100	$7,430
Exports:						
Quantity	metric tons	13,300	12,000	12,500	13,200	11,700
Value	thousands	$9,450	$9,620	$9,050	$10,700	$14,400
Imports for consumption:						
Quantity	metric tons	50,800	52,300	49,200	37,900	42,500
Value	thousands	$8,340	$8,010	$11,500	$8,890	$11,100
Apparent consumption[3]	metric tons	71,600	102,000	99,700	70,300	83,500
World, production	do.	1,370,000	1,380,000	1,310,000	1,390,000	1,410,000

do. Ditto.

[1] Data are rounded to no more than three significant digits.

[2] May exclude some unreported exports.

[3] Domestic production plus imports minus exports.

GEMSTONES

By Donald W. Olson

Domestic survey data and tables were prepared by Connie Lopez, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, the estimated value of natural gemstones produced in the United States was more than $10.0 million, and the estimated value of U.S. laboratory-created gemstone production was more than $30.8 million. The total estimated value of U.S. gemstone production was about $40.8 million. The value of U.S. gemstone imports was $19.6 billion, and the value of combined U.S. gemstone exports and reexports was estimated to be $14.9 billion.

In this report, the terms "gem" and "gemstone" mean any mineral or organic material (such as amber, pearl, petrified wood, and shell) used for personal adornment, display, or object of art because it possesses beauty, durability, and rarity. Of more than 4,000 mineral species, only about 100 possess all these attributes and are considered to be gemstones. Silicates other than quartz are the largest group of gemstones in terms of chemical composition; oxides and quartz are the second largest (table 1). Gemstones are subdivided into diamond and colored gemstones, which in this report designates all natural nondiamond gems. In addition, laboratory-created gemstones, cultured pearls, and gemstone simulants are discussed but are treated separately from natural gemstones (table 2). Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data. Current information on industrial-grade diamond and industrial-grade garnet can be found in the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals, chapters on industrial diamond and industrial garnet, respectively.

Gemstones have fascinated humans since prehistoric times. They have been valued as treasured objects throughout history by all societies in all parts of the world. Amber, amethyst, coral, diamond, emerald, garnet, jade, jasper, lapis lazuli, pearl, rock crystal, ruby, serpentine, and turquoise are some of the first stones known to have been used for making jewelry. These stones served as symbols of wealth and power. Today, gems are worn more for pleasure or in appreciation of their beauty than to demonstrate wealth. In addition to jewelry, gemstones are used for collections, decorative art objects, and exhibits.

Production

U.S. gemstone production data were based on a survey of more than 240 domestic gemstone producers conducted by the USGS. The survey provided a foundation for projecting the scope and level of domestic gemstone production during the year. However, the USGS survey did not represent all gemstone activity in the United States, which includes thousands of professional and amateur collectors. Consequently, the USGS supplemented its survey with estimates of domestic gemstone production from related published data, contacts with gemstone dealers and collectors, and information gathered at gem and mineral shows.

Commercial mining of gemstones has never been extensive in the United States. More than 60 varieties of gemstones have been produced commercially from domestic mines, but most of the deposits are relatively small compared with those of other mining operations. In the United States, much of the current gemstone mining is conducted by individual collectors, gem clubs, and hobbyists rather than by businesses.

The commercial gemstone industry in the United States consists of individuals and companies that mine gemstones or harvest shell and pearl, firms that manufacture laboratory-created gemstones, and individuals and companies that cut and polish natural and laboratory-created gemstones. The domestic gemstone industry is focused on the production of colored gemstones and on the cutting and polishing of large diamond stones. Industry employment is estimated to be between 1,000 and 1,200.

Most natural gemstone producers in the United States are small businesses that are widely dispersed and operate independently. The small producers probably have an average of less than three employees, including those who only work part time. The number of gemstone mines operating from year to year fluctuates because the uncertainty associated with the discovery and marketing of gem-quality minerals makes it difficult to obtain financing for developing and sustaining economically viable operations.

The total value of natural gemstones produced in the United States during 2010 was estimated to be about $10.0 million (table 3). This production value was an 8% increase from that of 2009.

Natural gemstone materials indigenous to the United States are collected or produced in every State. During 2010, all 50 States produced at least $1,360 worth of gemstone materials. There were 10 States that accounted for 85% of the total value, as reported by survey respondents. These States were, in descending order of production value, North Carolina, Arizona, Oregon, Utah, California, Tennessee, Montana, Colorado, Idaho, and Arkansas. Some States were known for the production of a single gemstone material—Tennessee for freshwater pearls, for example. Other States produced a variety of gemstones; for example, Arizona's gemstone deposits included agate, amethyst, azurite, chrysocolla, garnet, jade, jasper, malachite, obsidian, onyx, opal, peridot, petrified wood, smithsonite, and turquoise. There was also a wide variety of gemstones found and produced in California, Idaho, Montana, and North Carolina.

In 2010, the United States had only one active operation in a known diamond-bearing area in Crater of Diamonds State Park near Murfreesboro in Pike County, AR. The State of Arkansas maintains a dig-for-fee operation for tourists and rockhounds at the park; Crater of Diamonds is the only diamond mine in the world that is open to the public. The diamonds occur in a lamproite breccia tuff associated with a volcanic pipe and in the soil developed from the lamproite breccia tuff. In 2010, 601 diamond stones with an average weight of 0.218 carat were recovered at the Crater of Diamonds State Park. Of the 601 diamond stones recovered, 23 weighed more than 1 carat. Since the diamond-bearing pipe and the adjoining area became a State park in 1972, 29,906 diamond stones with a total carat weight of 5,981.1 have been recovered (Margi Jenks, park interpreter, Crater of Diamonds State Park, written commun., September 22, 2011). Exploration has demonstrated that this diamond deposit contains about 78.5 million metric tons (Mt) of diamond-bearing rock (Howard, 1999, p. 62). An Arkansas law enacted early in 1999 prohibits commercial diamond mining in the park (Diamond Registry Bulletin, 1999).

A few companies have expressed interest in exploration for diamond deposits in areas of Alaska, Colorado, Minnesota, Montana, and Wyoming with geologic settings and terrain that are similar to Canadian diamond mining areas. Even though some exploration has taken place in these States, they remain largely unexplored for diamonds (Iron Range Resources & Rehabilitation Board, 2012). Although exploration and field studies have found many diamond indicators and a number of large diamond deposits, none have attracted long-term investors or been operated commercially.

In addition to natural gemstones, laboratory-created gemstones and gemstone simulants were produced in the United States in 2010. Laboratory-created or synthetic gemstones have the same chemical, optical, and physical properties as the natural gemstones. Simulants have an appearance similar to that of a natural gemstone material, but they have different chemical, optical, and physical properties. Laboratory-created gemstones that have been produced in the United States include alexandrite, cubic zirconia, diamond, emerald, garnet, moissanite, ruby, sapphire, spinel, and turquoise. However, during 2010, only cubic zirconia, diamond, moissanite, and turquoise were produced commercially. Simulants of amber, chrysocolla, coral, lapis lazuli, malachite, travertine, and turquoise also were manufactured in the United States. In addition, certain colors of laboratory-created sapphire and spinel, used to represent other gemstones, are classified as simulants.

Laboratory-created gemstone production in the United States was valued at more than $30.8 million during 2010, which was a 13% increase compared with that of 2009. The value of U.S. simulant gemstone output was estimated to be more than $100 million. Five companies in five States, representing virtually the entire U.S. laboratory-created gemstone industry, reported production to the USGS. The States with reported laboratory-created gemstone production were, in descending order of production value, Florida, New York, Massachusetts, North Carolina, and Arizona.

Since the 1950s, when scientists manufactured the first laboratory-created bits of diamond grit using a high-pressure, high-temperature (HPHT) method, this method of growing diamonds has become relatively commonplace in the world as a technology for laboratory-created diamonds, so much so that thousands of small plants throughout China were using the HPHT method and producing laboratory-created diamonds suitable for cutting as gemstones. Gem-quality diamonds of 1 carat or more are harder to manufacture because at that size, it is difficult to consistently produce diamonds of high quality, even in the controlled environment of a laboratory using the HPHT method. After more than 50 years of development, that situation has changed, and several laboratory-created diamond companies were producing high-quality diamonds that equal those produced from mines (Park, 2007).

Gemesis Corp. (Sarasota, FL) consistently produced gem-quality laboratory-created diamond and reported an 11th year of production in 2010. The laboratory-created diamonds are produced using equipment, expertise, and technology developed by a team of scientists from Russia and the University of Florida. The weight of the laboratory-created diamond stones ranges from 1½ to 2 carats, and most of the stones are brownish yellow, colorless, green, and yellow. Gemesis uses diamond-growing machines, each machine capable of growing 3-carat rough diamonds by generating HPHT conditions that recreate the conditions in the Earth's mantle where natural diamonds form (Davis, 2003). Gemesis could be producing as many as 30,000 to 40,000 stones each year, and annual revenues may reach $70 million to $80 million. Gemesis diamonds are available for retail purchase in jewelry stores and on the Internet, and the prices of the Gemesis laboratory-created diamonds are 30% to 50% lower than those of comparable natural diamond but above the prices of simulated diamond (Gemesis Corp., 2010).

In the early 2000s, Apollo Diamond, Inc., near Boston, MA, developed and patented a method for growing single, extremely pure, gem-quality diamond crystals by chemical vapor deposition (CVD). The CVD technique transforms carbon into plasma, which is then precipitated onto a substrate as diamond. CVD had been used for more than a decade to cover large surfaces with microscopic diamond crystals, but in developing this process, Apollo Diamond discovered the temperature, gas composition, and pressure combination that resulted in the growth of a single diamond crystal. These CVD diamonds may not be distinguishable from natural diamond by some tests (Davis, 2003). Apollo Diamond produced laboratory-created stones that ranged from 1 to 2 carats. Growth of CVD diamonds is limited only by the size of the seed placed in the diamond-growing chamber. In 2008, the company increased its production of large stones and sold the diamonds at prices that averaged 15% less than those of comparable natural diamonds on the company Web site and through select jewelers (Apollo Diamond, Inc., 2008). Both Apollo Diamond and Gemesis prefer to call their diamonds "cultured" rather than laboratory-created, referring to the fact that the diamonds are grown much like a cultured pearl is grown.

In 2010, Charles & Colvard, Ltd. in North Carolina entered its 13th year as the world's only manufacturer of moissanite, a gem-quality laboratory-created silicon carbide. Moissanite is also an excellent diamond simulant, but it is being marketed for its own gem qualities. Moissanite exhibits a higher refractive index (brilliance) and higher luster than diamond. Its hardness is between those of corundum (ruby and sapphire) and diamond, which gives it durability (Charles & Colvard, Ltd., 2010). Charles & Colvard reported that moissanite sales increased by 53% to $12.7 million in 2010 compared with $8.3 million in 2009 (Charles & Colvard, Ltd., 2011).

U.S. mussel shells are used as a source of mother-of-pearl and as seed material for culturing pearls. U.S. shell production increased by 15% in 2010 compared with that of 2009 as were a reflection of the recovery from the impacts of the global recession on luxury spending. This increase was in spite of decreased demands for U.S. shell materials caused by the use of manmade seed materials and seed materials from China and other sources by pearl producers in Japan. The popularity of darker and colored pearls and freshwater pearls that do not use U.S. seed material has also contributed decreased demands for U.S. shell materials. In some regions of the United States, shell from mussels was being used more as a gemstone based on its own merit rather than as seed material for pearls. This shell material was being processed into mother-of-pearl and used in beads, jewelry, and watch faces.

Consumption

Historically, diamond gemstones have proven to hold their value despite wars or economic depressions, but this did not hold true during the recent worldwide economic recession. Diamond and colored gemstones value and sales decreased during the economic downturn in 2008 and continued into 2009, but during 2010 U.S. gemstone consumption and sales increased.

Although the United States accounted for little of the total global gemstone production, it was the world's leading diamond and nondiamond gemstone market. It was estimated that U.S. gemstone markets accounted for more than 35% of world gemstone demand in 2010. The U.S. market for unset gem-quality diamond during the year was estimated to be about $18.6 billion, an increase of 46% compared with that of 2009. Domestic markets for natural, unset nondiamond gemstones totaled approximately $959 million in 2010, which was a 23% increase from that of 2009. These large increases in domestic markets were a reflection of the recovery from the impacts of the global recession on luxury spending.

In the United States, a majority of domestic consumers designate diamond as their favorite gemstone. This popularity of diamonds is evidenced by the U.S. diamond market making up 95% of the total U.S. gemstone market. Colored natural gemstones, colored laboratory-created gemstones, and "fancy" colored diamonds were popular in 2010, with the values of the domestic markets for almost all types of colored natural, unset nondiamond gemstones increased from the 2009 values (table 10), also owing to recovery from the impact of the recession on luxury spending.

The estimated U.S. retail jewelry sales were $63.4 billion in 2010, an increase of 7.7% from sales of $58.8 billion in 2009 (Gassman, 2011). Twenty-five percent of all U.S. jewelers reported jewelry sales increased 20% or more from that of the previous year during the 2010 holiday shopping season (Graff, 2011).

Prices

Gemstone prices are governed by many factors and qualitative characteristics, including beauty, clarity, defects, demand, durability, and rarity. Diamond pricing, in particular, is complex; values can vary significantly depending on time, place, and the subjective valuations of buyers and sellers. There are more than 14,000 categories used to assess rough diamond and more than 100,000 different combinations of carat, clarity, color, and cut values used to assess polished diamond.

Colored gemstone prices are generally influenced by market supply and demand considerations, and diamond prices are supported by producer controls on the quantity and quality of supply. Values and prices of gemstones produced and (or) sold in the United States are listed in tables 3 through 5. In addition, customs values for diamonds and other gemstones imported, exported, or reexported are listed in tables 6 through 10.

De Beers Group companies remain a significant force, influencing the price of gem-quality diamond sales worldwide during 2010 because the companies mine a significant portion of the world's gem-quality diamond produced each year. In 2010, De Beers produced 33 million carats from its independently owned and joint-venture operations in Botswana, Canada, Namibia, and South Africa. De Beers companies also sorted and valuated a large portion (by value) of the world's annual supply of rough diamond through De Beers' subsidiary Diamond Trading Co. (DTC). DTC sales of rough diamonds totaled $5.08 billion during 2010—up $1.85 billion from 2009. DTC rough diamond average prices increased by 27% from those of 2009. In 2010, De Beers had diamond sales of $5.88 billion, which was an increase of 53% from diamond sales of 2009. These increases were driven by strong demand in Chinese and Indian markets (Lee, 2011).

Foreign Trade

During 2010, total U.S. gemstone trade with all countries and territories was valued at about $34.5 billion, which was a increase of 43% from that of 2009. Diamond accounted for about 95% of the 2010 gemstone trade total. In 2010, U.S. exports and reexports of diamond were shipped to 95 countries and territories, and imports of all gemstones were received from 99 countries and territories (tables 6–10). In 2010, U.S. import quantities in cut diamond increased by 24% compared with those of 2009, and their value increased by 45%. U.S. import quantities in rough and unworked diamond decreased by 44%, although their value increased by 81% (table 7). The United States remained the world's leading diamond importer and was a significant international diamond transit center as well as the world's leading gem-quality diamond market. In 2010, U.S. export quantities of gem-grade diamond increased by 80% compared with those of 2009, and their value increased by 33%. The large volume of reexports revealed the significance that the United States had in the world's diamond supply network (table 6). These increases in trade were owing to recovery from the impact of the recession on luxury spending.

Import values of laboratory-created gemstone increased by 10% for the United States in 2010 compared with those of 2009 (table 10). Again, this increase in imports was owing to recovery from the impact of the recession on luxury spending.

Laboratory-created gemstone imports from Austria, China, Germany, Hong Kong, India, Switzerland, and Thailand, with more than $500,000 in imports each, made up about 91% (by value) of the total domestic imports of laboratory-created gemstones during the year (table 9). The marketing of imported laboratory-created gemstones and enhanced gemstones as natural gemstones, and the mixing of laboratory-created materials with natural stones in imported parcels, continued to be problems for some domestic producers in 2009. There also were continuing problems with some simulants being marketed as laboratory-created gemstones during the year.

World Review

The gemstone industry worldwide has two distinct sectors—diamond mining and marketing and colored gemstone production and sales. Most diamond supplies are controlled by a few major mining companies; prices are supported by managing the quality and quantity of the gemstones relative to demand, a function performed by De Beers through DTC. Unlike diamond, colored gemstones are primarily produced at relatively small, low-cost operations with few dominant producers; prices are influenced by consumer demand and supply availability.

In 2010, world natural diamond production totaled about 144 million carats—79.9 million carats gem quality and 63.8 million carats industrial grade (table 11). Most production was concentrated in a few regions—Africa [Angola, Botswana, Congo (Kinshasa), Namibia, and South Africa], Asia (northeastern Siberia and Yakutia in Russia), Australia, North America (Northwest Territories in Canada), and South America (Brazil and Venezuela). In 2010, Russia led the world in total natural diamond output quantity (combined gemstone and industrial) with 23% of the world estimated production. Botswana was the world's leading gemstone diamond producer with 31%; followed by Russia, 22%; Angola, 16%; Canada, 15%; Congo (Kinshasa), 7%; South Africa, 4%; Namibia, 2%; and Guinea, 1%. These eight countries produced 97% (by quantity) of the world's gemstone diamond output in 2010.

In 2002, the international rough-diamond certification system, the Kimberley Process Certification Scheme (KPCS), was agreed upon by United Nations (UN) member nations, the diamond industry, and involved nongovernmental organizations to prevent the shipment and sale of conflict diamonds. Conflict diamonds are diamonds that originate from areas controlled by forces or factions opposed to legitimate and internationally recognized governments, and are used to fund military action in opposition to those governments, or in contravention of the decisions of the UN Security Council. The KPCS includes the following key elements: the use of forgery-resistant certificates and tamper-proof containers for shipments of rough diamonds; internal controls and procedures that provide credible assurance that conflict diamonds do not enter the legitimate diamond market; a certification process for all exports of rough diamonds; the gathering, organizing, and sharing of import and export data on rough diamonds with other participants of relevant production; credible monitoring and oversight of the international certification scheme for rough diamonds; effective enforcement of the provisions of the certification scheme through dissuasive and proportional penalties for violations; self regulation by the diamond industry that fulfills minimum requirements; and sharing information with all other participants on relevant rules, procedures, and legislation as well as examples of national certificates used to accompany shipments of rough diamonds. Israel assumed the chair of KPCS for January 1 through December 31, 2010, the eighth country or organization in succession to hold the chair after Namibia, India, South Africa, Canada, Russia, Botswana, and the European Commission. The 50 participants represented 76 nations (including the 27 member nations of the European Community) plus the rough diamond-trading entity of Taipei. During 2010, Côte d'Ivoire continued to be under UN sanctions and was not trading in rough diamonds, and Venezuela voluntarily suspended exports and imports of rough diamonds until further notice. The participating nations in the KPCS account for approximately 99.8% of the global production and trade of rough diamonds (Kimberley Process, undated).

Globally, the value of production of natural gemstones other than diamond was estimated to be more than $2.5 billion in 2010. Most nondiamond gemstone mines are small, low-cost, and widely dispersed operations in remote regions of developing nations. Foreign countries with major gemstone deposits other than diamond are Afghanistan (aquamarine, beryl, emerald, kunzite, lapis lazuli, ruby, and tourmaline), Australia (beryl, opal, and sapphire), Brazil (agate, amethyst, beryl, ruby, sapphire, topaz, and tourmaline), Burma (beryl, jade, ruby, sapphire, and topaz), Colombia (beryl, emerald, and sapphire), Kenya (beryl, garnet, and sapphire), Madagascar (beryl, rose quartz, sapphire, and tourmaline), Mexico (agate, opal, and topaz), Sri Lanka (beryl, ruby, sapphire, and topaz), Tanzania (garnet, ruby, sapphire, tanzanite, and tourmaline), and Zambia (amethyst and beryl). In addition, pearls are cultured throughout the South Pacific and in other equatorial waters; Australia, China, French Polynesia, and Japan were key producers in 2010.

Worldwide diamond exploration allocations decreased by 9% in 2010, to $357 million spent by 99 companies compared with $393 million by 113 companies during 2009. This lowered the diamond share of overall worldwide mineral exploration spending to 3% during 2010. Planned diamond exploration spending in 2010 was at its lowest value since 2003. Africa was the most popular diamond exploration location for the seventh year in a row, although Africa's share of overall exploration spending decreased to 35% in 2010 from almost 50% in 2009. Canada's share of total diamond exploration budgets increased to 29% in 2010 from 18% in 2009. De Beers Group dropped from the position of top diamond explorer that it had held for more than a decade and was replaced by ALROSA Co. Ltd. ALROSA, De Beers Group, and Rio Tinto plc were the three leading diamond exploration companies, accounting for 57% of the estimated $357 million total global diamond exploration budget in 2010 (Metals Economics Group, 2010, p. 8–9; 2011, p. 13).

Worldwide in 2010, diamond prices recovered strongly from the downturn caused by the global recession. The recovery was led by an upturn in the U.S. markets; this was demonstrated by increasing quantity and value of diamond imports in 2010 and improved sales in North America overall (Metals Economics Group, 2011, p. 10).

Worldwide in 2010, three diamond mines started up, including one mine reopening. One of the startups was in Botswana, one in Brazil, and the reopening was in South Africa (Metals Economics Group, 2011, p. 15).

Botswana.—Firestone Diamonds plc received a license for mining the BK11 Mine in July 2010, and began operating phase 1 of the production plant. Work on phase 2 was completed in the third quarter of 2010, increasing the ore production rate to 1.5 million metric tons (Mt) per year. The mine reached full production of 150,000 carats per year in the fourth quarter of 2010. The BK11 Mine is an open pit operation, which is 90% owned by Firestone Diamonds plc and 10% by a local company. Firestone estimated the BK11 Mine's reserves to be 18.0 Mt at startup (Metals Economics Group, 2011, p. 15).

Brazil.—During the third quarter of 2010, Vaaldiam Mining Inc. started production at its Duas Barras alluvial mining operation. Diamond recovery during the quarter was 643 carats from ore grading 0.03 carat per cubic meter. The ore grade improved after September with the opening of a second mining front that exposed large amounts of better quality gravels. The recovered diamond grade was approximately 0.16 carat per cubic meter. Vaaldiam estimated the reserves for Duas Barras at 2.3 Mt (Metals Economics Group, 2011, p. 15).

Canada.—Canadian diamond production was about 11.8 million carats (Mct) during 2010, an increase of about 8% compared with that of 2009. Diamond exploration continued in Canada, with several commercial diamond projects and additional discoveries in Alberta, British Columbia, the Northwest Territories, the Nunavut Territory, Ontario, and Quebec. In 2010, Canada produced 8.2% of the world's combined natural gemstone and industrial diamond output.

The Diavik Diamond Mine in the Northwest Territories completed its eighth full year of production. In 2010, Diavik produced 6.5 Mct of diamond, an increase of 16% from the previous year's production. At yearend 2010, Diavik estimated the mine's remaining proven and probable reserves to be 18 Mt of ore in kimberlite pipes containing 52.2 Mct of diamond and projected the total mine life to be 16 to 22 years. Diavik began developing an underground mine and substantially completed construction on the project during 2009, and the first ore was produced during the first quarter of 2010, with full production expected in 2013. The mine is an unincorporated joint venture between Diavik Diamond Mine Inc. (60%) and Harry Winston Diamond Mines Ltd. (40%) (Diavik Diamond Mine Inc., 2011; Perron, 2011, p. 2).

The Ekati Diamond Mine completed its twelfth full year of production in 2010. Ekati produced 2.89 Mct of diamond from 4.85 Mt of ore. BHP Billiton Ltd. has an 80% controlling ownership in Ekati, which also is in the Northwest Territories. Ekati has estimated remaining reserves of 38.5 Mt of ore in kimberlite pipes that contain 18.3 Mct of diamond. BHP Billiton projected the remaining mine life to be 12 years. Approximately 21% of the Ekati 2010 production is industrial-grade diamond (BHP Billiton Ltd., 2011, p. 10; Perron, 2011, p. 1).

The Jericho Diamond Mine is in Nunavut and was originally owned by Tahera Diamond Corp. Tahera estimated Jericho Diamond Mine's reserves to be about 5.5 Mt of ore grading 0.85 carat per ton. In 2008, the Jericho Diamond Mine experienced startup problems related to ore mining and processing. The mine also suffered financial problems owing to the cost of transporting supplies to the mine site, high operational costs, high oil prices, and appreciation of the Canadian dollar versus the U.S. dollar. All of these problems combined to force the company to enter into protection under Canada's "Companies' Creditors Arrangement Act" on January 16, 2008, and the mine suspended production on February 6, 2008. At yearend 2009, Tahera was finalizing arrangements to sell all of its Jericho Mine assets (Perron, 2011, p. 2). In July 2010, Shear Minerals Ltd. (now known as Shear Diamonds Ltd.) announced that it had entered into a purchase agreement with Tahera and Benachee Resources Inc. to acquire a 100% interest in the Jericho Diamond Mine, the mine's processing facilities, and all supporting exploration assets in the Kitikmeot region of Nunavut (Shear Minerals Ltd., 2010). Shear Minerals completed the acquisition of the Jericho Diamond Mine in August 2010 with the intention of bringing the mine back into production (Shear Minerals Ltd., 2011).

The Snap Lake Mine, which is wholly owned by De Beers Canada Inc., is in the Northwest Territories. The Snap Lake deposit is a tabular-shaped kimberlite dyke rather than the typical kimberlite pipe. The dyke is 2.5 meters thick and dips at an angle of 12° to 15°. The deposit was mined using a modified room and pillar underground mining method in 2010. The Snap Lake Mine started mining operations in October 2007, reached commercial production levels in the first quarter of 2008, and officially opened on June 25, 2008. The mine was expected to produce 1.4 Mct per year of diamond, and the mine life was expected to be about 20 years. The mine's production for 2010 was 926,000 carats for a recovered grade of 1.2 carats per metric ton (De Beers Canada Inc., 2011; Perron, 2011, p. 2–3).

The Victor Mine, which also is wholly owned by De Beers Canada, is in northern Ontario on the James Bay coast. The Victor kimberlite consists of two pipes with surface area of 15 hectares (37.1 acres). The Victor Mine initiated mining operations at yearend 2007 and was officially opened on July 26, 2008. The Victor Mine reportedly has 27.4 Mt of ore with average ore grade of 0.23 carat per metric ton estimated minable reserves. At full capacity, the open pit mine was expected to produce 600,000 carats per year, and the mine life was expected to be about 12 years. In 2010, the mine's production was 826,000 carats recovered from 2.67 Mt of ore (De Beers Canada Inc., undated; Perron, 2011, p. 3).

South Africa.—Petra Diamonds Ltd. has operated the Kimberley Underground Mines under care-and-maintenance status since 2007. De Beers had closed the mines in August 2005. In September 2007, Petra Diamonds began the process of purchasing De Beers interests in the mines and began rehabilitating the deep underground diamond mines. Petra Diamonds purchased the Kimberley diamond operations from De Beers for $11 million, and Petra Diamonds was given approval to operate the mines under De Beers' licence. After completing the mine rehabilitation, Petra Diamonds reopened the underground mine in September 2010. Petra had been producing from tailings and stockpile for the previous few years. During the fourth quarter of 2010, Kimberley produced 25,000 carats grading 0.14 carat per metric ton, and sold 17,300 carats at an average price of $285 per carat. The Kimberley Mines are 74% owned by Petra Diamonds and 26% by Sedibeng Mining (Pty) Ltd. Petra Diamonds estimated the Kimberley Mine's reserves to be 57.0 Mt. Kimberley's annual production was expected to be 100,000 carats from the processing of 1 Mt per year of ore (Metals Economics Group, 2011, p. 15; Petra Diamonds Ltd., undated).

Outlook

As the domestic and global economy improves, Internet sales of diamonds, gemstones, and jewelry were expected to continue to expand and increase in popularity, as were other forms of e-commerce that emerge to serve the diamond and gemstone industry. Internet sales are expected to add to and partially replace "brick-and-mortar" sales. This is likely to take place as the gemstone industry and its customers become more comfortable with and learn the applications of new e-commerce tools, such as sales Web sites and online social networking Web sites (Dayrit, 2011).

As more independent producers, such as Ekati and Diavik in Canada, come online they will bring a greater measure of competition to global markets that presumably will bring more supplies and lower prices. Further consolidation of diamond producers and larger quantities of rough diamond being sold outside DTC is expected to continue as the diamond industry adjusts to De Beers' reduced influence on the industry.

More laboratory-created gemstones, simulants, and treated gemstones are likely to enter the marketplace and necessitate more transparent trade industry standards to maintain customer confidence.

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TABLE 1
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Amber	Hydrocarbon	Yellow, red, green, blue	Any	Low to medium	2.0–2.5	1.0–1.1	Single	1.54	Synthetic or pressed plastics, kaurigum	Fossil resin, color, low density, soft, insects.
Apatite	Chlorocalcium phosphate	Colorless, pink, yellow, green, blue, violet	Small	Low	5.0	3.16–3.23	Double	1.63–1.65	Amblygonite, andalusite, brazilianite, precious beryl, titanite, topaz, tourmaline	Crystal habit, color, hardness, appearance.
Azurite	Copper carbonate hydroxide	Azure, dark blue, pale blue	Small to medium	do.	3.5–4.0	3.7–3.9	do.	1.72–1.85	Dumortierite, hauynite, lapis lazuli, lazulite, sodalite	Color, softness, crystal habits, associated minerals.
Benitoite	Barium titanium silicate	Blue, purple, pink, colorless	do.	High	6.0–6.5	3.64–3.68	do.	1.76–1.80	Sapphire, tanzanite, blue diamond, blue tourmaline, cordierite	Strong blue in ultraviolet light.
Beryl:										
Aquamarine	Beryllium aluminum silicate	Blue-green to light blue	Any	Medium to high	7.5–8.0	2.63–2.80	do.	1.58	Synthetic spinel, blue topaz	Double refraction, refractive index.
Bixbite	do.	Red	Small	Very high	7.5–8.0	2.63–2.80	do.	1.58	Pressed plastics, tourmaline	Refractive index.
Emerald, natural	do.	Green	Medium	do.	7.5	2.63–2.80	do.	1.58	Fused emerald, glass, tourmaline, peridot, green garnet doublets	Emerald filter, dichroism, refractive index.
Emerald, synthetic	do.	do.	Small	High	7.5–8.0	2.63–2.80	do.	1.58	Genuine emerald	Lack of flaws, brilliant fluorescence in ultraviolet light.
Golden (heliodor)	do.	Yellow to golden	Any	Low to medium	7.5–8.0	2.63–2.80	do.	1.58	Citrine, topaz, glass, doublets	Weak-colored.
Goshenite	do.	Colorless	do.	Low	7.5–8.0	2.63–2.80	do.	1.58	Quartz, glass, white sapphire, white topaz	Refractive index.
Morganite	do.	Pink to rose	do.	do.	7.5–8.0	2.63–2.80	do.	1.58	Kunzite, tourmaline, pink sapphire	Do.
Calcite:										
Marble	Calcium carbonate	White, pink, red, blue, green, or brown	do.	do.	3.0	2.72	Double (strong)	1.49–1.66	Silicates, banded agate, alabaster gypsum	Translucent.
Mexican onyx	do.	do.	do.	do.	3.0	2.72	do.	1.6	do.	Banded, translucent.
Charoite	Hydrated sodium calcium hydroxi-fluoro-silicate	Lilac, violet, or white	Small to medium	do.	5.0–6.0	2.54–2.78	XX	1.55–1.56	Purple marble	Color, locality.

See footnotes at end of table.

TABLE 1—Continued
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Chrysoberyl:										
Alexandrite	Beryllium aluminate	Green by direct sunlight, or encandescent light, red by indirect sunlight or fluorescent light	Small to medium	High	8.5	3.50–3.84	Double	1.75	Synthetic	Strong dichroism, color varies from red to green, hardness.
Cat's eye	do.	Greenish to brownish	do.	do.	8.5	3.50–3.84	do.	1.75	Synthetic, shell	Density, translucence, chatoyance.
Chrysolite	do.	Yellow, green, and (or) brown	Medium	Medium	8.5	3.50–3.84	do.	1.75	Tourmaline, peridot	Refractive index, silky.
Chrysocolla	Hydrated copper silicate	Green, blue	Any	Low	2.0–4.0	2.0–2.4	XX	1.46–1.57	Azurite, dyed chalcedony, malachite, turquoise, variscite	Lack of crystals, color, fracture, low density, softness.
Coral	Calcium carbonate	Orange, red, white, black, purple, or green	Branching, medium	do.	3.5–4.0	2.6–2.7	Double	1.49–1.66	False coral	Dull translucent.
Corundum:										
Ruby	Aluminum oxide	Rose to deep purplish red	Small	Very high	9.0	3.95–4.10	do.	1.78	Synthetics, including spinel, garnet	Inclusions, fluorescence.
Sapphire, blue	do.	Blue	Medium	High	9.0	3.95–4.10	do.	1.78	do.	Inclusions, double refraction, dichroism.
Sapphire, fancy	do.	Yellow, pink, colorless, orange, green, or violet	Medium to large	Medium	9.0	3.95–4.10	do.	1.78	Synthetics, glass and doublets, morganite	Inclusions, double refraction, refractive index.
Sapphire or ruby, stars	do.	Red, pink, violet, blue, or gray	do.	High to low	9.0	3.95–4.10	do.	1.78	Star quartz, synthetic stars	Shows asterism, color side view.
Sapphire or ruby, synthetic	do.	Yellow, pink, blue, green, orange, violet, or red	Up to 20 carats	Low	9.0	3.95–4.10	do.	1.78	Synthetic spinel, glass	Curved striae, bubble inclusions.
Cubic zirconia	Zirconium and yttrium oxides	Colorless, pink, blue, lavender, yellow	Small	do.	8.25–8.5	5.8	Single	2.17	Diamond, zircon, titania, moissanite	Hardness, density, lack of flaws and inclusions, refractive index.
Diamond	Carbon	White, blue-white, yellow, brown, green, red, pink, blue	Any	Very high	10.0	3.516–3.525	do.	2.42	Zircon, titania, cubic zirconia, moissanite	High index, dispersion, hardness, luster.
Feldspar:										
Amazonite	Alkali aluminum silicate	Green-blue	Large	Low	6.0–6.5	2.56	XX	1.52	Jade, turquoise	Cleavage, sheen, vitreous to pearly, opaque, grid.
Labradorite	do.	Gray with blue and bronze sheen color play (schiller)	do.	do.	6.0–6.5	2.56	XX	1.56	do.	Do.

See footnotes at end of table.

TABLE 1—Continued

GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Feldspar—*Continued:*										
Moonstone	Alkali aluminum silicate	Colorless, white, gray, or yellow with white, blue, or bronze schiller	Large	Low	6.0–6.5	2.77	XX	1.52–1.54	Glass, chalcedony, opal	Pale sheen, opalescent.
Sunstone	do.	Orange, red brown, colorless with gold or red glittery schiller	Small to medium	do.	6.0–6.5	2.77	XX	1.53–1.55	Aventurine, glass	Red glittery schiller.
Garnet	Complex silicate	Brown, black, yellow, green, red, or orange	do.	Low to high	6.5–7.5	3.15–4.30	Single strained	1.79–1.98	Synthetics, spinel, glass	Single refraction, anomalous strain.
Hematite	Iron oxide	Black, black-gray, brown-red	Medium to large	Low	5.5–6.5	5.12–5.28	XX	2.94–3.22	Davidite, cassiterite, magnetite, neptunite, pyrolusite, wolframite	Crystal habit, streak, hardness.
Jade:										
Jadeite	Complex silicate	Green, yellow, black, white, or mauve	Large	Low to very high	6.5–7.0	3.3–3.5	Crypto-crystalline	1.65–1.68	Nephrite, chalcedony, onyx, bowenite, vesuvianite, grossularite	Luster, spectrum, translucent to opaque.
Nephrite	Complex hydrous silicate	Green, yellow, black, white, or mauve	do.	Low to very high	6.0–6.5	2.96–3.10	do.	1.61–1.63	Jadeite, chalcedony, onyx, bowenite, vesuvianite, grossularite	Do.
Jet (gagate)	Lignite	Deep black, dark brown	do.	Low	2.5–4.0	1.19–1.35	XX	1.64–1.68	Anthracite, asphalt, cannel coal, onyx, schorl, glass, rubber	Luster, color.
Lapis lazuli	Sodium calcium aluminum silicate	Dark azure-blue to bright indigo blue or even a pale sky blue.	do.	do.	5.0–6.0	2.50–3.0	XX	1.5	Azurite, dumortierite, dyed howlite, lazulite, sodalite, glass	Color, crystal habit, associated minerals, luster, localities.
Malachite	Hydrated copper carbonate	Light to black-green banded	do.	do.	3.5–4.0	3.25–4.10	XX	1.66–1.91	Brochantite, chrysoprase, opaque green gemstones	Color banding, softness, associated minerals.
Moissanite	Silicon carbide	Colorless and pale shades of green, blue, yellow	Small	Low to medium	9.25	3.21	Double	2.65–2.69	Diamond, zircon, titania, cubic zirconia	Hardness, dispersion, lack of flaws and inclusions, refractive index.
Obsidian	Amorphous, variable (usually felsic)	Black, gray, brown, dark green, white, transparent	Large	Low	5.0–5.5	2.35–2.60	XX	1.45–1.55	Aegirine-augite, gadolinite, gagate, hematite, pyrolusite, wolframite	Color, conchoidal fracture, flow bubbles, softness, lack of crystal faces.

See footnotes at end of table.

TABLE 1—Continued

GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Opal	Hydrated silica	Reddish orange, colors flash in white gray, black, red, or yellow	Large	Low to high	5.5–6.5	1.9–2.3	Single	1.45	Glass, synthetics, triplets, chalcedony	Color play (opalescence).
Peridot	Iron magnesium silicate	Yellow and or green	Any	Medium	6.5–7.0	3.27–3.37	Double (strong)	1.65–1.69	Tourmaline, chrysoberyl	Strong double refraction, low dichroism.
Quartz:										
Agate	Silicon dioxide	Any	Large	Low	7.0	2.58–2.64	XX	XX	Glass, plastic, Mexican onyx	Cryptocrystalline, irregularly banded, dendritic inclusions.
Amethyst	do.	Purple	do.	Medium	7.0	2.65–2.66	Double	1.55	Glass, plastic, fluorite	Macrocrystalline, color, refractive index, transparent, hardness.
Aventurine	do.	Green, red-brown, gold-brown, with metallic iridescent reflection	do.	Low	7.0	2.64–2.69	do.	1.54–1.55	Iridescent analcime, aventurine feldspar, emerald, aventurine glass	Macrocrystalline, color, metallic iridescent flake reflections, hardness.
Cairngorm	do.	Smoky orange or yellow	do.	do.	7.0	2.65–2.66	do.	1.55	do.	Macrocrystalline, color, refractive index, transparent, hardness.
Carnelian	do.	Flesh red to brown red	do.	do.	6.5–7.0	2.58–2.64	do.	1.53–1.54	Jasper	Cryptocrystalline, color, hardness.
Chalcedony	do.	Bluish, white, gray	do.	do.	6.5–7.0	2.58–2.64	do.	1.53–1.54	Tanzanite	Do.
Chrysoprase	do.	Green, apple-green	do.	do.	6.5–7.0	2.58-2.64	Double	1.53–1.54	Chrome chalcedony, jade, prase opal, prehnite, smithsonite, variscite, artificially colored green chalcedony	Do.
Citrine	do.	Yellow	do.	do.	7.0	2.65–2.66	do.	1.55	do.	Macrocrystalline, color, refractive index, transparent, hardness.
Jasper	do.	Any, striped, spotted, or sometimes uniform	do.	do.	7.0	2.58–2.66	XX	XX	do.	Cryptocrystalline, opaque, vitreous luster, hardness.
Onyx	do.	Many colors	do.	do.	7.0	2.58–2.64	XX	XX	do.	Cryptocrystalline, uniformly banded, hardness.

See footnotes at end of table.

TABLE 1—Continued
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Quartz—Continued:										
Petrified wood	Silicon dioxide	Brown, gray, red, yellow	Large	Low	6.5–7.0	2.58–2.91	Double	1.54	Agate, jasper	Color, hardness, wood grain.
Rock crystal	do.	Colorless	do.	do.	7.0	2.65–2.66	do.	1.55	Topaz, colorless sapphire	Do.
Rose	do.	Pink, rose red	do.	do.	7.0	2.65–2.66	do.	1.55	do.	Macrocrystalline, color, refractive index, transparent, hardness.
Tiger's eye	do.	Golden yellow, brown, red, blue-black	do.	do.	6.5-7.0	2.58–2.64	XX	1.53–1.54	XX	Macrocrystalline, color, hardness, chatoyancy.
Rhodochrosite	Manganese carbonate	Rose-red to yellowish, stripped	do.	do.	4.0	3.45–3.7	Double	1.6–1.82	Fire opal, rhodonite, tugtupite, tourmaline	Color, crystal habit, reaction to acid, perfect rhombohedral cleavage.
Rhodonite	Manganese iron calcium silicate	Dark red, flesh red, with dendritic inclusions of black manganese oxide	do.	do.	5.5–6.5	3.40–3.74	do.	1.72–1.75	Rhodochrosite, thulite, hessonite, spinel, pyroxmangite, spessartine, tourmaline	Color, black inclusions, lack of reaction to acid, hardness.
Shell:										
Mother-of-pearl	Calcium carbonate	White, cream, green, blue-green, with iridescent play of color	Small	do.	3.5	2.6–2.85	XX	XX	Glass and plastic imitation	Luster, iridescent play of color.
Pearl	do.	White, cream to black, sometimes with hint of pink, green, purple	do.	Low to high	2.5–4.5	2.6–2.85	XX	XX	Cultured and glass or plastic imitation	Luster, iridescence, x-ray of internal structure.
Spinel, natural	Magnesium aluminum oxide	Any	Small to medium	Medium	8.0	3.5–3.7	Single	1.72	Synthetic, garnet	Refractive index, single refraction, inclusions.
Spinel, synthetic	do.	do.	Up to 40 carats	Low	8.0	3.5–3.7	Double	1.73	Spinel, corundum, beryl, topaz, alexandrite	Weak double refraction, curved striae, bubbles.
Spodumene:										
Hiddenite	Lithium aluminum silicate	Yellow to green	Medium	Medium	6.5–7.0	3.13–3.20	do.	1.66	Synthetic spinel	Refractive index, color, pleochroism.
Kunzite	do.	Pink to lilac	do.	do.	6.5–7.0	3.13–3.20	Double	1.66	Amethyst, morganite	Do.
Tanzanite	Complex silicate	Blue to lavender	Small	High	6.0–7.0	3.3	do.	1.69	Sapphire, synthetics	Strong trichroism, color.
Topaz	Lithium aluminum silicate	White, blue, green, pink, yellow, gold	Medium	Low to medium	8.0	3.4–3.6	do.	1.62	Beryl, quartz	Color, density, hardness, refractive index, perfect in basal cleavage.
Tourmaline	do.	Any, including mixed	do.	do.	7.0–7.5	2.98–3.20	do.	1.63	Peridot, beryl, garnet corundum, glass	Double refraction, color, refractive index.

See footnotes at end of table.

TABLE 1—Continued
GUIDE TO SELECTED GEMSTONES AND GEM MATERIALS USED IN JEWELRY

Name	Composition	Color	Practical size[1]	Cost[2]	Mohs	Specific gravity	Refraction	Refractive index	May be confused with	Recognition characteristics
Turquoise	Copper aluminum phosphate	Blue to green with black, brown-red inclusions	Large	Low	6.0	2.60–2.83	Double	1.63	Chrysocolla, dyed howlite, dumortierite, glass, plastics, variscite	Difficult if matrix not present, matrix usually limonitic.
Unakite	Granitic rock, feldspar, epidote, quartz	Olive green, pink, and blue-gray	do.	do.	6.0–7.0	2.60–3.20	XX	XX	XX	Olive green, pink, gray-blue colors.
Zircon	Zirconium silicate	White, blue, brown, yellow, or green	Small to medium	Low to medium	6.0–7.5	4.0–4.8	Double (strong)	1.79–1.98	Diamond, synthetics, topaz, aquamarine	Double refraction, strongly dichroic, wear on facet edges.

Do., do. Ditto. XX Not applicable.

[1] Small: up to 5 carats; medium: 5 to 50 carats; large: more than 50 carats.

[2] Low: up to $25 per carat; medium: up to $200 per carat; high: more than $200 per carat.

TABLE 2
LABORATORY-CREATED GEMSTONE PRODUCTION METHODS

Gemstone	Production method	Company/producer	Date of first production
Alexandrite	Flux	Creative Crystals Inc.	1970s.
Do.	Melt pulling	J.O. Crystal Co., Inc.	1990s.
Do.	do.	Kyocera Corp.	1980s.
Do.	Zone melt	Seiko Corp.	Do.
Cubic zirconia	Skull melt	Various producers	1970s.
Emerald	Flux	Chatham Created Gems	1930s.
Do.	do.	Gilson	1960s.
Do.	do.	Kyocera Corp.	1970s.
Do.	do.	Lennix	1980s.
Do.	do.	Russia	Do.
Do.	do.	Seiko Corp.	Do.
Do.	Hydrothermal	Biron Corp.	Do.
Do.	do.	Lechleitner	1960s.
Do.	do.	Regency	1980s.
Do.	do.	Russia	Do.
Ruby	Flux	Chatham Created Gems	1950s.
Do.	do.	Douras	1990s.
Do.	do.	J.O. Crystal Co., Inc.	1980s.
Do.	do.	Kashan Created Ruby	1960s.
Do.	Melt pulling	Kyocera Corp.	1970s.
Do.	Verneuil	Various producers	1900s.
Do.	Zone melt	Seiko Corp.	1980s.
Sapphire	Flux	Chatham Created Gems	1970s.
Do.	Melt pulling	Kyocera Corp.	1980s.
Do.	Verneuil	Various producers	1900s.
Do.	Zone melt	Seiko Corp.	1980s.
Star ruby	Melt pulling	Kyocera Corp.	Do.
Do.	do.	Nakazumi Earth Crystals Co.	Do.
Do.	Verneuil	Linde Air Products Co.	1940s.
Star sapphire	do.	do.	Do.

Do., do. Ditto.

TABLE 3
ESTIMATED VALUE OF U.S. NATURAL GEMSTONE PRODUCTION, BY GEM TYPE[1]

(Thousand dollars)

Gem materials	2009	2010
Beryl	918 r	1,700
Coral, all types	150	150
Diamond	(2)	(2)
Garnet	148	149
Gem feldspar	858	693
Geode/nodules	105	110
Opal	225	189
Quartz:		
Macrocrystalline[3]	231	273
Cryptocrystalline[4]	216	208
Sapphire/ruby	256	344
Shell	713	821
Topaz	(2)	(2)
Tourmaline	112	95
Turquoise	531	449
Other	4,850	4,840
Total	9,310 r	10,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

[3] Macrocrystalline quartz (crystals recognizable with the naked eye) includes amethyst, aventurine, blue quartz, citrine, hawk's eye, pasiolite, prase, quartz cat's eye, rock crystal, rose quartz, smoky quartz, and tiger's eye.

[4] Cryptocrystalline quartz (microscopically small crystals) includes agate, carnelian, chalcedony, chrysoprase, fossilized wood, heliotrope, jasper, moss agate, onyx, and sard.

TABLE 4

PRICES PER CARAT OF U.S. CUT ROUND DIAMONDS, BY SIZE AND QUALITY IN 2010

Carat weight	Description, color[2]	Clarity[1] (GIA terms)	Representative prices		
			January[3]	June[4]	December[5]
0.25	G	VS1	$1,400	$1,400	$1,400
Do.	G	VS2	1,300	1,300	1,300
Do.	G	SI1	1,200	1,200	1,200
Do.	H	VS1	1,350	1,350	1,350
Do.	H	VS2	1,250	1,250	1,250
Do.	H	SI1	1,150	1,150	1,150
0.50	G	VS1	2,650	2,650	2,650
Do.	G	VS2	2,200	2,200	2,200
Do.	G	SI1	1,900	1,900	1,900
Do.	H	VS1	2,350	2,350	2,350
Do.	H	VS2	2,150	2,150	2,150
Do.	H	SI1	1,800	1,800	1,800
1.00	G	VS1	6,400	6,400	6,400
Do.	G	VS2	5,450	5,450	5,450
Do.	G	SI1	4,650	4,650	4,650
Do.	H	VS1	5,300	5,300	5,300
Do.	H	VS2	4,800	4,800	4,800
Do.	H	SI1	4,225	4,225	4,225
2.00	G	VS1	11,400	11,900	12,100
Do.	G	VS2	10,900	11,200	11,500
Do.	G	SI1	8,800	8,800	9,100
Do.	H	VS1	9,300	9,300	9,500
Do.	H	VS2	9,000	9,000	9,100
Do.	H	SI1	8,000	8,000	8,250

Do. Ditto.

[1] Clarity: IF—no blemishes; VVS1—very, very slightly included; VS1—very slightly included; VS2—very slightly included, but not visible; SI1—slightly included.

[2] Gemological Institute of America (GIA) color grades: D—colorless; E—rare white; G, H, I—traces of color.

[3] Source: The Gem Guide, v. 29, no. 1, January/February 2010, p. 20–22.

[4] Source: The Gem Guide, v. 29, no. 4, July/August 2010, p. 20–22.

[5] Source: The Gem Guide, v. 29, no. 6, November/December 2010, p. 20–22.

TABLE 5
PRICES PER CARAT OF U.S. CUT COLORED GEMSTONES IN 2010

Gemstone	Price range per carat	
	January[1]	December[2]
Amethyst	$10–25	$10–25
Blue sapphire	900–1,650	950–1,800
Blue topaz	5–10	5–10
Emerald	2,400–4,000	2,400–4,000
Green tourmaline	50–70	50–70
Cultured saltwater pearl[3]	5	5
Pink tourmaline	70–150	70–150
Rhodolite garnet	20–40	22–45
Ruby	1,850–2,200	1,850–2,200
Tanzanite	300–375	300–375

[1] Source: The Gem Guide, v. 29, no. 1, January/February 2010, p. 48, 51, 55, 59, 61, 63, and 66–69. These figures are approximate wholesale purchase prices paid by retail jewelers on a per stone basis for 1 to less than 1 carat fine-quality stones.

[2] Source: The Gem Guide, v. 29, no. 6, November/December 2010, p. 50, 53, 57, 61, 63, 65, and 68–71. These figures are approximate wholesale purchase prices paid by retail jewelers on a per-stone basis for 1 to less than 1 carat fine-quality stones.

[3] Prices are per 4.5–5-millimeter pearl.

TABLE 6
U.S. EXPORTS AND REEXPORTS OF DIAMOND (EXCLUSIVE OF INDUSTRIAL DIAMOND), BY COUNTRY[1]

	2009		2010	
Country	Quantity (carats)	Value[2] (millions)	Quantity (carats)	Value[2] (millions)
Exports:				
Australia	37,600	$21	33,000	$34
Belgium	300,000	150	346,000	396
Canada	46,600	70	52,000	87
Costa Rica	8,470	2	9,430	2
France	49,200	25	33,000	94
Hong Kong	807,000	380	1,910,000	448
India	962,000	477	1,300,000	825
Israel	960,000	482	419,000	365
Japan	17,800	5	3,400	9
Mexico	504,000	79	561,000	84
Netherlands	561	1	1,150	9
Netherlands Antilles	10,600	23	12,700	34
Singapore	31,200	13	8,690	10
South Africa	829	2	636	7
Switzerland	152,000	146	147,000	177
Taiwan	12,900	5	9,080	4
Thailand	86,700	40	92,500	14
United Arab Emirates	108,000	46	193,000	68
United Kingdom	27,400	58	325,000	58
Other	156,000	133	2,250,000	139
Total	4,280,000	2,160	7,710,000	2,860
Reexports:				
Armenia	1,670	(3)	1,880	(3)
Australia	59,600	19	16,300	16
Belgium	4,130,000	1,110	2,410,000	1,600
Canada	139,000	127	143,000	144
Dominican Republic	15,300	3	10,500	1
France	80,800	43	47,900	78
Guatemala	50,300	5	46,000	5
Hong Kong	3,220,000	1,190	4,340,000	1,820
India	2,350,000	959	2,730,000	1,900
Israel	6,940,000	2,750	4,390,000	4,110
Japan	117,000	24	98,200	32
Malaysia	9,860	1	2,480	2
Mexico	2,990	2	5,780	1
Singapore	193,000	50	65,500	24
South Africa	66,500	55	29,300	45
Switzerland	584,000	492	429,000	565
Thailand	145,000	29	160,000	31
United Arab Emirates	749,000	198	338,000	188
United Kingdom	383,000	204	166,000	269
Other	1,710,000	534	598,000	407
Total	20,900,000	7,780	16,000,000	11,200
Grand total	25,200,000	9,940	23,700,000	14,100

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF DIAMOND, BY KIND, WEIGHT, AND COUNTRY[1]

Kind, range, and country of origin	2009 Quantity (carats)	2009 Value[2] (millions)	2010 Quantity (carats)	2010 Value[2] (millions)
Rough or uncut, natural:[3]				
Angola	359,000	$48	67,000	$132
Australia	17,700	2	8,060	1
Botswana	88,100	35	81,500	68
Brazil	443	(4)	--	--
Canada	27,300	32	35,300	43
Congo (Kinshasa)	11,600	7	6,650	7
Ghana	250	(4)	135	(4)
Guyana	212	(4)	534	(4)
India	32,700	1	12,900	1
Namibia	10,000	6	7,450	9
Russia	16,500	3	37,500	8
South Africa	104,000	112	102,000	223
Other	32,000	43	29,400	31
Total	700,000	289	389,000	524
Cut but unset, not more than 0.5 carat:				
Belgium	344,000	127	281,000	106
Canada	7,910	7	13,000	9
China	25,800	18	37,500	21
Dominican Republic	38,200	10	7,250	2
Hong Kong	239,000	24	180,000	25
India	5,760,000	1,150	7,310,000	1,560
Israel	400,000	198	433,000	207
Mauritius	6,920	15	5,780	15
Mexico	65,900	10	92,300	21
South Africa	1,780	10	9,440	13
Thailand	60,800	17	93,400	14
United Arab Emirates	153,000	30	77,100	17
Other	57,400	39 r	63,900	49
Total	7,160,000	1,650	8,610,000	2,060
Cut but unset, more than 0.5 carat:				
Belgium	640,000	2,130	706,000	2,900
Canada	20,200	60	23,300	83
Hong Kong	26,800	76	42,200	102
India	1,110,000	1,930	1,900,000	3,610
Israel	1,670,000	5,350	2,000,000	7,530
Mexico	1,810	3	1,250	1
Russia	57,800	137	25,300	98
South Africa	34,700	533	63,000	892
Switzerland	23,500	238	11,300	391
Thailand	3,980	9	5,910	13
United Arab Emirates	33,900	60	10,100	42
Other	53,200	256	73,800	343
Total	3,670,000	10,800	4,860,000	16,000

ʳRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Includes some natural advanced diamond.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES, OTHER THAN DIAMOND, BY KIND AND COUNTRY[1]

Kind and country	2009 Quantity (carats)	2009 Value[2] (millions)	2010 Quantity (carats)	2010 Value[2] (millions)
Emerald:				
Belgium	1,980	$1	1,340	(3)
Brazil	500,000	7	120,000	$7
Canada	434	(3)	4	(3)
China	4,150	(3)	13,800	1
Colombia	314,000	120	406,000	131
France	315	2	1,480	2
Germany	8,470	2	54,000	2
Hong Kong	334,000	23	246,000	17
India	2,410,000	18	1,810,000	37
Israel	181,000	20	172,000	17
Italy	2,380	1	2,880	(3)
Switzerland	7,980	8	6,290	13
Thailand	292,000	8	487,000	10
United Kingdom	356	1	1,550	2
Other	38,000	3	89,400	15
Total	4,090,000	214	3,410,000	254
Ruby:				
Belgium	10	(3)	16	(3)
China	2,100	(3)	19,200	(3)
France	37	(3)	1,730	(3)
Germany	8,370	(3)	10,900	(3)
Hong Kong	420,000	1	201,000	1
India	2,500,000	2	2,310,000	6
Israel	5,560	1	22,300	(3)
Italy	1,330	(3)	4,300	(3)
Kenya	16,700	(3)	1,810	(3)
Sri Lanka	2,020	1	3,800	(3)
Switzerland	933	3	129	2
Thailand	1,750,000	14	1,880,000	22
United Arab Emirates	64	2	210	(3)
Other	179,000	13	168,000	11
Total	4,880,000	37	4,630,000	42
Sapphire:				
Australia	2,340	(3)	1,190	(3)
Austria	472	(3)	3,380	(3)
Belgium	283	1	2,420	1
China	122,000	1	56,700	3
Dominican Republic	600	(3)	--	--
Germany	33,200	5	123,000	4
Hong Kong	610,000	13	536,000	9
India	2,140,000	6	2,570,000	20
Israel	9,780	1	19,300	2
Italy	15,000	1	5,440	1
Singapore	3,010	(3)	--	--
Sri Lanka	240,000	31	309,000	66
Switzerland	14,700	14	13,700	20
Thailand	1,730,000	48	2,630,000	78
United Arab Emirates	2,530	2	319	(3)
United Kingdom	504	1	610	1

See footnotes at end of table.

TABLE 8—Continued
U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES, OTHER THAN DIAMOND, BY KIND AND COUNTRY[1]

Kind and country	2009 Quantity (carats)	2009 Value[2] (millions)	2010 Quantity (carats)	2010 Value[2] (millions)
Sapphire—Continued:				
Other	68,200	$3	44,800	$8
Total	4,990,000	127	6,320,000	214
Other:				
Rough, uncut, all countries	NA	8	NA	15
Cut, set and unset, all countries	NA	29	NA	32

NA Not available. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9
VALUE OF U.S. IMPORTS OF LABORATORY-CREATED AND IMITATION GEMSTONES, BY COUNTRY[1, 2]

(Thousand dollars)

Country	2009	2010
Laboratory-created, cut but unset:		
Austria	1,430	1,950
Brazil	374	96
Canada	9	--
China	7,600	5,700
Czech Republic	42	118
France	284	232
Germany	11,100	10,100
Hong Kong	455	549
India	2,180	9,870
Italy	95	78
Japan	61	25
Korea, Republic of	46	53
Netherlands	5	29
Sri Lanka	315	35
Switzerland	797	500
Taiwan	161	186
Thailand	975	723
United Arab Emirates	98	--
Other	3,390	2,050
Total	29,500	32,300
Imitation:[3]		
Austria	47,100	51,400
Brazil	2	--
China	13,300	13,300
Czech Republic	5,080	5,070
France	--	5
Germany	566	726
Hong Kong	358	158
India	302	125
Italy	123	164
Korea, Republic of	131	282
Taiwan	--	25
Thailand	39	28
United Kingdom	3	--
Other	208	406
Total	67,200	71,700

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Includes pearls.

Source: U.S. Census Bureau.

TABLE 10

U.S. IMPORTS FOR CONSUMPTION OF GEMSTONES[1]

(Thousand carats and thousand dollars)

Stones	2009		2010	
	Quantity	Value[2]	Quantity	Value[2]
Coral and similar materials, unworked	4,430	10,500	5,760	12,000
Diamonds:				
Cut but unset	10,800	12,400,000 r	13,500	18,100,000
Rough or uncut	700	289,000	389	524,000
Emeralds, cut but unset	4,090	214,000	3,140	254,000
Pearls:				
Cultured	NA	26,900	NA	15,800
Imitation	NA	4,150	NA	5,100
Natural	NA	21,100	NA	22,900
Rubies and sapphires, cut but unset	9,880	164,000	10,900	256,000
Other precious and semiprecious stones:				
Rough, uncut	1,080,000	15,000	1,400,000	30,700
Cut, set and unset	NA	247,000	NA	276,000
Other	91,100	11,600	78,100	11,300
Laboratory-created:				
Cut but unset	8,730	29,500	6,800	32,300
Other	NA	8,240	NA	14,600
Imitation gemstone[3]	NA	67,200	NA	66,600
Total	1,200,000	13,500,000 r	1,520,000	19,600,000

[r] Revised. NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Does not include pearls.

Source: U.S. Census Bureau.

TABLE 11

NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE[1, 2, 3]

(Thousand carats)

Country and type[4]	2006	2007	2008	2009	2010
Gemstones:					
Angola	8,258	8,732	8,016	12,445	12,500 [e]
Armenia	184	123	101	50	50 [e]
Australia	7,305	231	273	220 [r, e]	100 [e]
Botswana[e]	24,000	25,000	25,000	24,000	25,000
Brazil[e]	181	182	182	200 [r, 5]	200
Canada	13,278	17,144	14,803	10,946	11,773
Central African Republic[e]	340	370	302 [r, 5]	249 [r, 5]	250
China[e]	100	100	100	100	100
Congo (Kinshasa)	5,800	5,700	4,200	3,700 [r]	5,500
Côte d'Ivoire[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Ghana	768	671	478	301 [r]	300 [e]
Guinea	355	815	2,500	557 [r]	550
Guyana	341	269	169	144	144 [e]
Lesotho	231	454	450 [e]	450 [e]	460
Namibia	2,400	2,266	2,435	1,192 [r]	1,200 [e]
Russia[e]	23,400	23,300	21,925 [5]	17,791 [5]	17,800
Sierra Leone	362	362	223	241 [r]	240 [e]
South Africa[e]	6,100	6,100	5,200	2,500 [r]	3,500
Tanzania[e]	230	239	202	155 [r]	77
Venezuela[e]	45	45	45	45	45
Zimbabwe[e]	160	100	100	100	50
Other[6]	70	75 [r]	121 [r]	79 [r]	70
Total	93,900 [r]	92,300 [r]	86,800 [r]	75,500 [r]	79,900
Industrial:					
Angola[e]	918	970	900	1,383 [r, 5]	1,300
Australia	21,915	18,960	15,397	10,700	9,900
Botswana[e]	8,000	8,000	8,000	7,000	7,000
Brazil[e]	600	600	600	600	600
Central African Republic[e]	85	93	74 [5]	62 [r, 5]	60
China[e]	965	970	1,000	1,000	1,000
Congo (Kinshasa)	23,100	22,600	16,700	14,600 [r]	22,200
Côte d'Ivoire[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Ghana	192	168	120	75 [r]	75 [e]
Guinea	118	200	600	139 [r]	130
Russia[e]	15,000	15,000	15,000	15,000	15,000
Sierra Leone	241	241	149	160 [r]	160 [e]
South Africa[e]	9,100	9,100	7,700	3,600 [r]	5,400
Tanzania[e]	42	44	36 [r]	27	14
Venezuela[e]	70	70	70	70	70
Zimbabwe[e]	900	600	700	850 [r]	800
Other[7]	67	84 [r]	145 [r]	115 [r]	118
Total	81,300 [r]	77,700 [r]	67,200 [r]	55,400 [r]	63,800
Grand total	175,000 [r]	170,000 [r]	154,000 [r]	131,000 [r]	144,000

[e] Estimated. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 2, 2011.

[3] In addition to the countries listed, Nigeria and the Republic of Korea produce natural diamond and synthetic diamond, respectively, but information is inadequate to formulate reliable estimates of output levels.

TABLE 11—Continued

NATURAL DIAMOND: WORLD PRODUCTION, BY COUNTRY AND TYPE [1, 2, 3]

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[4] Includes near-gem and cheap-gem qualities.

[5] Reported figure.

[6] Includes Cameroon, Congo (Brazzaville), Gabon (unspecified), India, Indonesia, Liberia, and Togo (unspecified).

[7] Includes Congo (Brazzaville), India, Indonesia, and Liberia.

GERMANIUM

By David E. Guberman

The table was prepared by Robin C. Kaiser, statistical assistant.

In 2010 in the United States, germanium-bearing concentrates were produced at a zinc mine in Alaska owned by Teck Resources Ltd. (Vancouver, British Columbia, Canada). The germanium-bearing concentrates were exported to Canada for processing or directly to customers in Asia and Europe. Two refineries in New York and Oklahoma produced germanium dioxide, germanium metal, and germanium tetrachloride from manufacturers' scrap, post-consumer scrap, and processed imported germanium compounds.

Germanium is a hard, brittle semimetal that first was used about a half century ago as a semiconductor material in radar units and as the material for the first transistors. Today, it is used principally as a polymerization catalyst for polyethylene terephthalate (PET), a commercially important plastic; as a component of glass in telecommunications fiber optics; as a lens or window in infrared night-vision devices; and as a semiconductor and substrate in electronic circuitry and solar cells.

Legislation and Government Programs

As a strategic and critical material, germanium was included in the National Defense Stockpile in 1984. The Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center) reported that there were no germanium metal sales in 2010 compared with 68 kilograms (kg) in 2009. Germanium was last sold in February 2009 at an average price of $1,331 per kilogram. As of December 31, 2010, the total inventory of germanium metal held by the DLA was 16,362 kg valued at $17.3 million.

During fiscal year 2010 (October 1, 2009, through September 30, 2010), the DLA did not sell any units of germanium metal. The DLA announced that beginning June 1, germanium would be offered on a quarterly basis instead of monthly as it had in the past. The Annual Materials Plan for fiscal year 2011 (October 1, 2010, through September 30, 2011) did not allocate for sale any germanium metal (Defense Logistics Agency, DLA Strategic Materials, 2010; 2011).

Production

The multiple stages of the germanium production process yield germanium compounds and metals that are associated with specific applications. Germanium is initially recovered from the leaching of zinc residues or coal ash and the subsequent precipitation of a germanium concentrate. All germanium concentrates are purified using similar techniques, regardless of the source of the concentrates. The concentrated germanium is chlorinated and distilled to form the first usable product, germanium tetrachloride, a colorless liquid that is primarily used as a reagent in fiber-optic cable production. Germanium tetrachloride can be hydrolyzed and dried to produce germanium dioxide, another commonly used compound. Germanium dioxide appears as a white powder and is used to manufacture certain types of optical lenses and as a catalyst in the production of PET resin. Germanium dioxide can be reduced with hydrogen to produce a germanium metal powder, which is subsequently melted and cast into first-reduction bars. The germanium bars are then zone-refined (a refining process that involves melting and cooling germanium bars to isolate and remove impurities and ultimately yield extremely pure germanium) to produce electronic-grade germanium metal. Zone-refined germanium metal can then be grown into crystals and sliced for use as semiconductors or recast into forms suitable for lenses or window blanks in infrared optical devices.

In 2010, germanium was not recovered from zinc concentrates or coal in the United States. Domestic refinery production of germanium was estimated by the U.S. Geological Survey (USGS) based on data provided by North American producers. The USGS estimated that U.S. refinery production of germanium metal from imported primary material and germanium compounds was about 9,300 kg. Domestic refinery production of germanium metal recovered from end-of-life products, such as decommissioned military vehicles and thermal weapons sights, was estimated to be about 3,000 kg in 2010.

Teck Alaska Inc. (a wholly owned subsidiary of Teck Resources) produced germanium-containing zinc concentrates at its Red Dog zinc-lead open pit mine in Alaska. Approximately 25% of the zinc concentrate produced at Red Dog was sent to Teck's metallurgical complex in Trail, British Columbia, Canada. Residues from zinc concentrates were treated in roasters or pressure-leach facilities and purified to produce germanium dioxide, germanium tetrachloride, and other byproduct metals. Teck reported that zinc and lead concentrate production at Red Dog in 2010 was less than that of 2009 owing to a decrease in mill feed grades (Teck Resources Ltd., 2011, p. 32–34).

In 2010, Umicore Optical Materials USA Inc. (a subsidiary of Umicore s.a., Brussels, Belgium) continued production of germanium metal and compounds at its plant in Quapaw, OK, and remained the leading domestic producer of germanium and germanium-base materials. Umicore recovered and refined germanium from industry-generated new scrap and from imported germanium compounds. The Quapaw facility refined the material into germanium tetrachloride, germanium metal, and proprietary [chalcogenide glass (GASIR®)] lenses, which were designed for large-scale commercial and military infrared optical systems. In 2010, construction work was completed on a new germanium substrate plant in Quapaw that was expected to nearly double Umicore's global wafer production capacity to about 1 million substrates (10 centimeter diameter) per year. The 3,720-square-meter plant was modeled after Umicore's germanium substrate facility in Olen, Belgium, and was built adjacent to Umicore's existing operations in Quapaw. The company expected global demand for germanium substrates used in solar cells and light-emitting diodes (LEDs) to increase significantly during the next several years (Umicore s.a., 2010c; 2011, p. 26).

Germanium Corp. of America (a subsidiary of Indium Corp. of America, Clinton, NY) produced germanium products, including germanium dioxide, germanium metal, and germanium tetrachloride at its facility in Utica, NY.

In May 2009, Nyrstar N.V. (Balen, Belgium), a leading global zinc and lead producer, announced that it had acquired the idled Middle Tennessee zinc mining complex near Gordonsville, TN, from Mid-Tennessee Zinc Corp. for about $13.3 million. The complex consisted of zinc mines in Cumberland, Elmwood, and Gordonsville, TN, which had historically produced zinc concentrates containing germanium and gallium. Nyrstar also owned the Clarksville, TN, smelter, which was originally built to treat concentrates from the Middle Tennessee zinc mining complex, and the mine complex was expected to be an important source of concentrate for the Clarksville zinc smelter. Nyrstar began ramping up production at the mines in 2010 and by yearend, the Middle Tennessee Mines were operating at about 35% of total production capacity, producing 13,000 metric tons (t) of zinc in concentrate. Nyrstar expected to have the mines operating at full capacity in early 2011. Nyrstar had not publicly released details of plans to recover germanium from zinc residues by yearend 2010 (Nyrstar N.V., 2011, p. 13).

Consumption

The USGS estimated that domestic apparent consumption of germanium increased by about 3% to 40,000 kg in 2010 from 38,800 kg in 2009 (revised) owing to increased demand for germanium for use in electronic, fiber-optic, infrared-optic, and solar-cell applications. Worldwide, the end-use pattern of germanium was estimated to be as follows: infrared optics, 30%; fiber optics, 20%; catalysts for PET, 20%; electronics and solar applications, 15%; and other uses (such as phosphors, metallurgy, and chemotherapy), 15%. The domestic end-use pattern, however, was different, with infrared optics accounting for 50%; fiber optics, 30%; electronics and solar applications, 15%; and other uses (phosphors, metallurgy, and chemotherapy), 5%. Germanium was not used in PET catalysts in the United States.

Infrared Systems.—Germanium was used in the manufacture of lenses and windows for infrared optical systems owing to its transparency to part of the infrared spectrum and to its high refractive index. Germanium is easily machinable, relatively strong, resistant to atmospheric oxidation, and able to withstand exposure to chemicals and moisture. The lenses and windows manufactured from germanium are often incorporated into thermal imaging systems that detect infrared radiation and convert it into an electronic signal, which is then processed and displayed on a video screen. Thermal imaging systems are different from other types of "low light" vision systems in that they are not adversely affected by the presence of light, so they can be used day or night. It was estimated that about 60% of lower- and midrange infrared-optical systems and 50% of all high-end devices used lenses made from germanium crystals.

According to the most recent data available, the sales value of the global infrared thermal imaging market was estimated to be about $6.6 billion. Military and other government applications represented 88% of this market, with commercial applications accounting for the remaining 12%. All branches of the military continued to rely heavily on infrared devices for around-the-clock force protection and intelligence, surveillance, and reconnaissance (ISR) as well as target acquisition applications on multiple platforms. Products used by the military typically range in price from under $10,000 for hand-held and weapon-mounted systems to more than $1 million for advanced stabilized targeting systems. The majority of infrared imaging systems use cooled technology to identify objects from long distances; however, uncooled thermal imaging systems were growing rapidly in certain markets such as weapon sights, hand-held monoculars/binoculars, military vehicles, and unmanned aerial vehicles. These devices are substantially smaller and more lightweight than their cooled counterparts because they operate at ambient temperatures while retaining their sensitivity to infrared light. Air-, land-, and sea-based vehicles were routinely equipped with multiple infrared systems that allowed soldiers to perform a variety of combat-related functions in even the most adverse battlefield conditions. A typical ground transport vehicle might be outfitted with separate infrared imaging systems for driver and observer's vision enhancers, weapons sights, and roof-mounted imaging systems that perform long-range scans in search of improvised explosive devices. A leading domestic producer of infrared devices for military use reported a reduction in procurement activity by the U.S. Government in 2010 compared with that in 2009 (FLIR Systems, Inc., 2011, p. 41).

Many of the thermal imaging manufacturers have made efforts to enter the commercial market to pursue growth opportunities that are expected in the near future. As the cost of infrared imaging technology has declined, demand has increased in markets such as airborne law enforcement, automotive night-vision, commercial security, firefighting, and recreational marine applications. Hand-held thermal imaging systems that can detect and measure small temperature differences were used for a variety of commercial and industrial applications, such as predictive and preventive maintenance. A leading thermal imaging device manufacturer reported that its revenue from commercial vision systems increased at a compound annual rate of 25% from 2005 to 2009 (FLIR Systems, Inc., 2010, p. 1).

Fiber Optics.—In the fiber-optics sector, germanium tetrachloride is converted to germanium dioxide and used as a dopant (a substance added in small amounts to the pure silica glass core to increase its refractive index, preventing signal loss while not absorbing light) within the core of optical fibers. In 2010, an estimated $300 billion of capital expenditure was dedicated globally to construction and improvements of telecommunication infrastructure. Growth areas that utilize fiber-optics to meet increasing demand for more bandwidth included enterprise data-storage applications, fiber-to-the-home (FTTH) installations, and wireless communications networks. Demand for fiber-optic cable in North America has been increasing at a slower rate during the last couple of years compared with that of 2008, reflective of an overall reduction in business activity owing to the global financial slowdown. In September 2010, the Fiber-to-the-Home Council estimated that about 20 million homes in North America had FTTH connectivity available at the premises compared with 17.2 million in September 2009. Producers of germanium tetrachloride for fiber optics and fiber-optic cable producers indicated that sales volumes in 2010 were slightly greater than those in 2009. A leading manufacturer of fiber-optic cable indicated that net sales for their telecommunications segment in 2010 were greater than those in 2009 owing to increased sales of enterprise network products and optical fiber and cable in North America and Europe that were offset somewhat by declining sales of fiber-to-the-premises products and optical fiber and cable products in Asia (Fiber-to-the-Home Council, 2010; Corning Inc., 2011, p. 32).

Solar Cells.—The use of germanium as a substrate in the production of solar cells is segmented into two markets—space-based applications and terrestrial installations. Demand for satellites has increased steadily from 2007 to 2010 owing to demand for commercial, military, and scientific applications. It was estimated that about 400,000 germanium substrates were consumed each year for space-based applications, and the majority of all satellites were powered by germanium-based solar cells. Germanium substrates were smaller in size and weight, more efficient at converting light into energy, and provided greater power output than the most common alternative substrate, silicon. Germanium substrates constitute the building blocks of multilayer (often referred to as multijunction) solar cells. Ultrathin layer combinations of materials, such as gallium, indium, phosphide, and gallium arsenide, are "grown" on top of the germanium substrate, each capturing a specific part of the solar spectrum and converting it into electricity. The solar energy conversion efficiency of these multijunction cells was typically greater than 25%. Currently, triple-junction cells are most common, but technological advancements have allowed for multijunction cells to combine more layers and junctions onto one cell, increasing performance capabilities. In late 2010, Spectrolab Inc. (a subsidiary of The Boeing Co.), in Sylmar, CA, produced its 3 millionth multijunction space-based solar cell. In 2010, the company provided the NASA Jet Propulsion Laboratory with panels containing germanium-based multijunction solar cells for the first mission to Jupiter powered by solar cells. The company began adapting space-based solar technology for terrestrial applications in 2001 and has been able to convert concentrated sunlight to electricity at efficiencies as great as 41.6%. In 2010, Spectrolab expected to deliver 50 megawatts (MW) of solar cells to terrestrial-based solar cell customers and expected that number to triple in 2011 (Spectrolab Inc., 2010; Umicore s.a., 2010a, p. 52).

Several other manufacturers of germanium substrates, multijunction solar cells, and solar systems have focused capital investment and research efforts on the emerging terrestrial solar market. While there is fairly widespread agreement that global demand for solar power generation and other sources of renewable energy will continue to increase during the next several decades, multiple solar cell technologies will compete for a portion of the solar power market. The multijunction solar cells that use germanium substrates and germanium layers are typically more expensive to manufacture than other technologies, such as cadmium telluride, crystalline silicon, or copper-indium-gallium diselenide thin-film cells, but are considerably more efficient at converting solar energy into electricity so fewer cells are required in a panel to produce equivalent amounts of power. To obtain the most energy possible from each multijunction cell in a solar panel, concentrator photovoltaic (CPV) technology is used. A concentrator system uses optics (mirrors or lenses) to focus high concentrations of direct sunlight onto the solar cells. The lenses or mirrors concentrate sunlight hundreds of times before it reaches the solar cell, making each cell more efficient. Concentrating panels must receive direct sunlight to operate so CPV installations are limited to geographic regions that receive proper levels of sunlight. CPV systems typically require tracking systems that allow the solar panels to follow the Sun's path during the day. CPV systems are marketed to the large-scale power generation industry and not considered a feasible solar power option for private homeowners.

As of 2009, CPV installations in China, Europe, and North America had about 24.5 megawatts (MW) of electrical generating capacity. By yearend 2009, new CPV projects under development in the United States were expected to increase electrical generating capacity by about 17 MW. It was estimated that, in current CPV installations, 1 MW of solar power generation capacity required about 10 kg of germanium contained in 1,500 substrates. Multijunction solar cells have continued to become a viable option for use in large-scale concentrated solar power projects because their energy conversion efficiencies have been increasing at a rate of about 1% per year during the past decade. The Federal Government has also been actively involved in advancing solar energy technologies, including CPV systems. The U.S. Department of Energy (DOE) Solar Energy Technologies Program (SETP) was aggressively funding a diverse set of photovoltaic (PV) technologies that had potential applications in a range of different markets. Through its primary research and development efforts, the PV subprogram's goal was for PV technology to achieve grid parity (the point at which the cost of generating electricity using alternative technologies such as solar power is at least equal to the cost of generating electricity from conventional sources such as burning coal) by 2015. In 2010, the DOE was also ramping up its concentrating solar power (CSP) research, development, and deployment efforts. The DOE's goals included increasing the use of CSP in the United States, making CSP competitive in the intermediate power market by 2015, and developing advanced technologies that would reduce systems and storage costs, enabling CSP to be competitive in the baseload power market by 2020. Separately, Emcore Corp. (Albuquerque, NM) was collaborating with the National Renewable Energy Laboratory and the U.S. Air Force Research Laboratory to develop new advanced multijunction solar cells that could achieve greater conversion efficiencies than existing multijunction cells. These new inverted metamorphic multijunction cells were built using a different manufacturing process where the layers of the semiconductor were grown "upside down" on the germanium substrate so that the top layer of the cell is grown on the bottom of the stack, closest to the substrate. When completed, the cell is removed from the germanium substrate and encapsulated. The process allows for higher quality development of the most important layer of the solar cell, the top layer, and had the potential to achieve energy conversion efficiencies of 50% in the future (Umicore s.a, 2010b, p. 5; Emcore Corp., 2011a, p. 16–17; 2011b, p. 9; U.S. Department of Energy, 2011).

Electronic Components.—Germanium substrate consumption for production of high-brightness LEDs used in such devices as automobile taillights, cameras, flashlights, mobile telephone display screens, televisions, and traffic signals increased in 2010 compared with that in the previous year. In electronics, silicon germanium (SiGe) components have replaced gallium arsenide in some high-tech products, such as components for cellular telephones. In high-speed wireless telecommunications devices, SiGe transistors can attain greater switching speeds and require less power than traditional, silicon-base components, increasing overall performance. In 2010, Samsung Electronics Co., Ltd. (Seoul, Republic of Korea) announced plans to produce phase change memory modules made from an alloy of antimony, germanium, and titanium that could potentially boost battery life in mobile devices by as much as 20% compared with the current flash memory technology used in those devices. SiGe-base microchips were also used in radar systems for automobiles to increase driving safety. Known as radar-on-chip-for-cars technology, these devices are capable of alerting drivers of impediments that are in the path of the vehicle in order to prevent potential accidents. A joint research cooperation project, supported by a financial grant from the German Federal Ministry of Education and Research, was launched in mid-2009 to advance this technology and make it available in all vehicle classes. Several automobile manufacturers and suppliers were working with semiconductor manufacturer Infineon Technologies AG (Neubiberg, Germany) on this project to develop new, cost-effective SiGe-chip-based automotive radar systems (Infineon Technologies AG, 2009; PC Magazine, 2010).

Polymerization Catalysts.—Outside the United States, estimates indicated that germanium dioxide used as a catalyst for PET production has declined since 2007. Japan continued to be the leading consumer of germanium for this application. Demand for germanium dioxide used in PET was estimated to be about 17,200 t in 2010, down from about 23,500 t in 2009. An increase in recycling rates of PET-based products and an increase in PET substitution contributed to the decline in germanium dioxide consumption. Substitutes, including antimony trioxide and titanium, had the potential to replace the relatively expensive germanium as a catalyst in the future (Roskills Letters from Japan, 2010, p. 8–11; 2011, p. 26).

Prices

Germanium prices were relatively volatile during 2008 through 2010. The annual average price of germanium metal has increased or decreased by 20% or more from that of the previous year nearly every year since 2000. The downturn in the global economy in 2009 caused germanium prices to decline significantly from the peaks of 2008, and prices remained at those 2009 levels during most of 2010. The market prices of germanium dioxide and metal were relatively stable during the first three quarters of 2010 and increased in the last quarter. Free market prices for germanium dioxide in 2010, published by Metal-Pages, began the year at about $580 per kilogram and increased by 24% to $720 per kilogram by yearend. The free market prices for germanium metal began the year at $940 per kilogram and increased by 28% to $1,200 per kilogram by yearend 2010.

Based on DLA Strategic Materials reports, the unit price of zone-refined germanium metal in inventory that was authorized for disposal as of December 2010 was $1,057 per kilogram.

Foreign Trade

According to the U.S. Census Bureau, imports for consumption of germanium metal (wrought, unwrought, and powder) decreased by 8% to 27,000 kg in 2010 from 29,400 kg in 2009. Decreased imports from Belgium, Canada, and Russia outweighed increases from China. In 2010, China, Russia, and Germany, in descending order of quantity, accounted for 93% of germanium metal imported into the United States (table 1). The estimated germanium content of the germanium dioxide imported in 2010 was about 17,700 kg compared with 27,500 kg (revised) in 2009. Canada accounted for about 66% of total germanium dioxide imports in 2010.

Domestic exports of germanium metal and articles thereof, including waste and scrap, were 8,000 kg in 2010, based on an analysis of trade data from the U.S. Census Bureau. Belgium, Canada, and Russia accounted for the majority of germanium exported from the United States in 2010. The estimated germanium content of germanium dioxide exported from the United States in 2010 was less than 100 kg.

World Review

In 2010, the world's total production of germanium was estimated to be between 100 and 120 t. This comprised germanium recovered from zinc concentrates, fly ash from burning coal, and recycled material. The recycling level remained about the same as that in 2009 and supplied about 30% of the world's total supply of germanium. Owing to the value of refined germanium, new scrap generated during the manufacture of fiber-optic cables, infrared optics, and substrates is typically reclaimed and fed back into the production process. Recycling of germanium recovered from used materials, such as fiber-optic window blanks in decommissioned military vehicles or fiber-optic cables, has increased during the past decade. Worldwide, primary germanium was recovered from copper or zinc residues or from coal in Canada (concentrates shipped from the United States), China (multiple sources), Finland [concentrates from Congo (Kinshasa)], and Russia (lignite coal from Sakhalin). The vast majority of germanium production was concentrated in Canada and China.

Many germanium-related projects that were in exploratory or early development stages in 2008 when germanium prices were at elevated levels were halted or delayed in 2009 when prices declined. Some germanium producers reduced production in early 2009 to avoid stockpiling material that became more difficult to sell in a surplus market. As a byproduct metal, the supply of germanium was heavily reliant on zinc production, which declined on a global basis in 2009 owing to price declines and global economic conditions. Market conditions for germanium remained relatively stable during the first three quarters of 2010, and most potential production projects were put on hold. Demand appeared to strengthen during the last quarter of the year, and prices increased during that time period as readily available supplies became tighter than they had been in the earlier parts of the year.

European Union.—The European Union (EU) has become more concerned about the security of its raw materials supply during the past several years and has initiated analysis of minerals and materials that were expected to have increased economic and technological value in the future. In June, the European Commission (EC) included germanium in a list of 14 raw materials of critical concern for members of the EU owing to their expected economic importance and relative supply risk and provided policy-oriented recommendations to ensure access to these resources in the future. A working group established by the EC analyzed 41 metals and minerals and concluded that 14 of them could be termed critical for the EU supply during the next 10 years based on each material's level of production, recycling rate, and the availability of substitutes. Many of the materials on the list were considered supply risks owing to global production being highly concentrated in a single country. The study indicated that Brazil, China, Congo (Kinshasa), and Russia were producing a significant portion of the 14 raw materials that were considered critical. The working group suggested policy actions for the EU to follow in order to avoid potential shortages of the critical materials in the future. Recommendations included policy actions that would encourage the substitution of noncritical materials for critical ones if possible, improve the recycling rates for raw materials, and promote exploration and research (Metal Bulletin, 2010).

Belgium.—Umicore produced germanium metal, germanium tetrachloride for fiber optics, germanium substrates, and germanium optical products at its refining and recycling plant in Olen. The company also operated an electro-optic materials research and design facility in Olen. Umicore's substrate manufacturing facility had the capacity to produce about 600,000 germanium substrates (100 millimeters in diameter) per year. In 2010, Umicore's Electro-Optic Division reported that sales volumes of germanium substrates had increased compared with those of the previous year. Demand had increased for germanium substrates used in space- and terrestrial-based applications and for use in LEDs. The company reported that demand for optics from government-sponsored programs was relatively weak during 2010. Sales volumes of germanium tetrachloride were relatively unchanged in 2010 compared with those in the previous year and were primarily driven by fiber-optic network projects in China (Umicore s.a., 2011, p. 26).

Canada.—The metallurgical complex operated by Teck in Trail consisted of six major metallurgical plants, one fertilizer plant, and two specialty metal plants that produced byproduct metals, including germanium and indium. Teck has historically been one of the leading germanium producers in the world. Teck did not disclose germanium production information to the public for 2010. The last year that the company had made germanium production information available was 2007, when Teck produced about 40,000 kg of germanium dioxide at Trail. Germanium was produced as a byproduct of the leaching of zinc concentrates, and in 2010, Teck's production of refined zinc from concentrates at Trail increased by 13% to 278,000 t of refined zinc from 240,000 t of refined zinc produced in 2009. Teck had curtailed zinc production at Trail in 2009 in response to the deteriorating market conditions for zinc. It was not known what effect, if any, this reduction in zinc production had on the level of germanium production in 2009. Based on trade data published by the Canadian Government, Canada exported about 29,400 kg of germanium contained in germanium dioxide in 2010 compared with about 36,000 kg in 2009 (revised). The leading destinations, in order of importance, of exported germanium dioxide were the United States, 38%; Japan, 28%; North Korea, 16%; and the Republic of Korea, 14% (Statistics Canada, 2011; Teck Resources Ltd., 2011, p. 35).

In March, 5N Plus Inc. (Montreal, Quebec), a producer and provider of high-purity metals and compounds for electronic applications, announced that its wholly owned subsidiary [Firebird Technologies Inc. (Trail, British Columbia)] had entered into a long-term supply agreement with Teck for germanium and indium feedstocks. Under the terms of the agreement, Teck was to provide a long-term stable supply of germanium and indium for Firebird to process into downstream products such as semiconductor wafers, semifinished optics, and high-purity metals and compounds. In June, 5N Plus entered into a supply agreement with Sylarus Technologies, LLC (St. George, UT), a North American producer of germanium substrates for solar cells used in satellites and high-efficiency terrestrial installations. Under the terms of the agreement, 5N Plus would provide Sylarus with germanium feedstock and also recycle byproducts of Sylarus' germanium substrate manufacturing (5N Plus Inc., 2010, American Metal Market, 2010).

China.—China continued to be the leading global producer of germanium metal and germanium compounds. In 2010, five to six producers accounted for the majority of the estimated 85 to 100 t of germanium metal and germanium compounds produced in China. About 44% of this production was in the form of germanium metal, 42% was germanium dioxide (metal content), and 14% was in the form of other compounds. Germanium-bearing coal ash and zinc ore were the sources for the Chinese germanium production. The germanium market slowed during the second half of 2008, and this slowdown continued until the fourth quarter of 2010. From June 2008 to June 2009, the market price of germanium metal in China declined by more than 33% to less than $1,000 per kilogram from $1,500 per kilogram. Domestic germanium prices remained at these levels during the first three quarters of 2010. Domestic producers had difficulty selling germanium compounds and metal even at the lower price levels owing to lackluster demand, and some decided to stockpile germanium or curtail production until prices increased again. Producers were not willing to sell germanium metal at prices that approached their production costs, and consumers of the material tried to buy smaller quantities than usual in anticipation of further price declines. The market changed significantly during the fourth quarter of 2010 as prices increased steeply, approaching levels of late 2008, and producer stocks became tighter. The change in the domestic market during this time period was attributed to a combination of factors. The available supply of germanium was tightened by the announcement of strategic stockpiling initiatives at the National and Provincial level and the forced closure of some germanium producing smelters owing to environmental concerns. Internal demand from consumers of germanium in China had also increased as more companies attempted to export value-added products instead of raw materials. A 5% export tax on germanium dioxide had encouraged producers to develop downstream production capabilities in recent years, and Chinese exports have shifted to germanium metal and finished products such as fiber optics and optical lenses. This has reduced the amount of Chinese-produced germanium dioxide that reached the global market in 2010 (Metal-Pages, 2010b; 2011).

In late 2010, China announced that it had set aside more than $4 billion for one of the largest "treasure hunts" for new resources in the country's recent history. The government was looking for new deposits of iron ore, copper, chromium, manganese, tungsten, germanium, indium, and rare-earth elements according to the Chinese ministry of land resource at a forum in Henan Province. The plan involved large-scale prospecting operations in all of China's Provinces, with a focus on 45 key prospecting areas. Provinces and regions of particular interest included Hunan, Inner Mongolia, Jiangxi, Qinghai, Shanxi, and Yunnan (Metal-Pages, 2010a).

Japan.—The Japanese markets for germanium products have moved in diverging directions since 2008. Demand for germanium tetrachloride has been strong and increased during that time period, but consumption of germanium dioxide and germanium metal have declined. The growth in germanium tetrachloride consumption between 2008 and 2010 was driven by the fiber-optic industry. Japanese production of fiber-optic cable increased by 14% from 2008 to 2009, and the majority of these cables were exported to China and India, where infrastructure development has been increasing. Conversely, Japanese demand for germanium dioxide, mainly used as a catalyst in PET production, has declined significantly. In 2010, Japan imported 17,200 kg of germanium dioxide, a decrease of 17% from 23,500 kg imported in 2009 and a decrease of 46% from 31,700 kg 2008. Factors that have contributed to the decline in consumption were increased use of less expensive antimony-based catalysts, increased use of recycled catalysts, and reductions in the thickness of PET bottles. Canada has emerged as the primary source of imported germanium dioxide since 2008. In 2010, 81% of the germanium dioxide imported was from Canada. Before 2008, the majority of this material had come from China. Consumers of germanium dioxide reduced imports from China in favor of long-term contacts with Canadian suppliers as Chinese supply tightened and prices increased. Chinese germanium dioxide imports to Japan declined by 88% from 2007 to 2009 (Roskill's Letters from Japan, 2010; 2011).

Namibia.—Emerging Metals Ltd. (Douglas, United Kingdom), a mineral exploration company, was investigating the possibility of extracting germanium from the slag stockpiles near the town of Tsumeb. In January 2008, Emerging Metals had purchased an option to acquire processing and ownership rights to the Tsumeb slag stockpiles from Ongopolo Mining Ltd. [a wholly owned subsidiary of Weatherly International plc (London, United Kingdom)]. In 2009, the company continued studies and test work on the slag stockpiles to determine the viability of extracting the contained metals, principally germanium but also gallium and zinc. In March 2010, the directors of the company decided to exit the Tsumeb slag stockpiles project altogether owing to weak market conditions for the metals of interest (Emerging Metals Ltd., 2010, p. 2).

Outlook

Global germanium consumption is likely to increase during the next several years owing to the growth that is expected in the major end-use sectors. Germanium-based optical blanks and windows that are incorporated in infrared devices were expected to continue to be heavily used by military and law enforcement agencies. New applications for these products in commercial and industrial markets also were expected to become more prevalent and represented a large potential growth area. Global demand for fiber-optic cable, led by the emerging Asian economies, had been forecast to increase at a compound annual growth rate of 8% through 2012. Global support for the increased use of solar energy during the next several years is expected to increase demand for germanium substrates that are used to manufacture high-efficiency multijunction solar cells. New satellites launched for defense and private industry uses were expected to continue to fuel consumption of germanium substrates in solar cells. As energy conversion efficiencies continue to improve, terrestrial-based solar systems will be a more feasible option for large-scale power generation. Owing to the massive size of the installations, growth in the terrestrial-based solar cell market could significantly boost annual germanium substrate consumption (Mikolajczak, 2010).

Germanium substrates used in thermophotovoltaic (TPV) cells that convert heat radiation (instead of sunlight) generated from sources such as furnaces or water boilers into electricity could be a future growth area. Most TPV cells were used almost exclusively for military applications, but this technology could be applied in industrial or residential settings. In an industrial setting, for example, TPV cells could generate electricity from the heat created during the production of materials such as glass or steel.

On the supply side, the redevelopment of existing zinc mines in Tennessee could be a new domestic source of germanium during 2011 though 2013. Several germanium recovery projects in China that were in late stages of development or early production also could bring more germanium to the market if demand continues to increase. In addition to primary germanium production, the availability of recycled germanium recovered from end-of-life products, such as fiber optics, military vehicles, and solar cells, was expected to increase during the next couple of decades as these aging products are taken out of service. Overall, the germanium market is expected to remain tight during the next several years owing to the emerging end uses and limited sources of supply.

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TABLE 1

U.S. IMPORTS FOR CONSUMPTION OF GERMANIUM METAL, BY COUNTRY[1,2]

	2009		2010	
Country	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Belgium	5,490	$5,960,000	1,560	$2,700,000
Canada	796	425,000	70	15,500
China	14,000	14,800,000	18,100	14,500,000
France	124	91,100	70	70,300
Germany	2,360	4,290,000	2,320	3,310,000
Hong Kong	363	380,000	--	--
Japan	203	185,000	--	--
Russia	5,980	8,900,000	4,620	3,450,000
United Kingdom	53	33,800	--	--
Other	38	4,030,000	312	1,840,000
Total	29,400	39,100,000	27,000	25,900,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Data include wrought, unwrought, and powder, but exclude germanium dioxide.

Source: U.S. Census Bureau.

GOLD

By Micheal W. George

Domestic survey data and tables were prepared by Wanda G. Wooten, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, domestic mine production of gold increased to 231,000 kilograms (kg), 4% more than that in 2009 (tables 1–2). This marks the first increase in 10 years, although production was 37% lower than the historical high of 366,000 kg in 1998. In 2010, the value of domestic production increased to $9.13 billion, up 30% compared with that in 2009 because of the increase in the price of gold and the increase in domestic production. It was the ninth straight year that the value had increased. Gold recovery from the major mines in Nevada decreased because mining lower grade ore was more profitable with high gold price. Decreased production from mines processing lower grade ore were offset by production from Barrick Gold Corp.'s (Toronto, Ontario, Canada) new pit at the Cortez Mine. In 2010, production began at the Kensington Mine in Alaska, the Jerritt Canyon Mine restarted production, and the Deep Post Mine in Nevada reached its end of life. Price increases have spurred domestic exploration and development of new gold projects. Mines in Nevada and Alaska accounted for almost 72% and 12%, respectively, of domestic gold production in 2010. The remaining production came from mines in Utah, Colorado, Washington, California, South Dakota, Arizona, and Idaho, in descending order of production. Gold was produced at lode mines in Alaska, California, Colorado, Nevada, South Dakota, Utah, and Washington, at two large placer mines in Alaska, and numerous small placer mines, mostly in Alaska and the Western States. In addition, domestic gold was produced as a byproduct of processing base metals, primarily copper. In the United States, the 30 leading operations yielded 99% of the gold produced (table 3).

In 2010, the domestic nonfuel mineral exploration budget increased to $850 million, a 63% increase compared with that in 2009. Much of the increase was a result of increased exploration for copper and gold targets in Alaska and gold targets in Nevada. Major reasons for increased exploration were the improved economy and higher commodity prices. In 2010, gold was the primary mineral exploration target and represented more than 50% of the worldwide nonferrous exploration budget. In 2010, the gold exploration budget was $5.4 billion, which was 59% more than that in 2009. Gold exploration in Canada, Australia, and the United States, in descending order, represented more than 40% of the global gold exploration budget. In 2010, the worldwide nonferrous exploration budget rose to $10.7 billion, a 44% increase compared with that of 2009 (Lowrey, 2010; Wilburn, 2011, p. 58–60).

U.S. jewelry manufacturing was heavily concentrated in the New York, NY, and Providence, RI, areas, with other manufacturers in California, Florida, and Texas. Commercial-grade refined gold was produced by about two dozen domestic companies. Of several thousand companies and artisans, a few dozen companies dominated the fabrication of gold into commercial products. In 2010, the estimated percentages for end use of gold were jewelry and arts, 54%; dental and medical, 10%; electrical and electronics, 7%; and other, 29%.

Refined bullion comprised 33% of U.S. gold imports and 77% of exports; the United States was a net exporter of 95,700 kg of bullion in 2010 (tables 4, 6). The imports and exports of gold bullion increased by 57% and 5%, respectively, from those in 2009. The increases in imports mainly were from Canada and Mexico, which provided almost 51% and 25%, respectively, of the refined bullion imported. Imports of ores and concentrates increased by 450% because of a substantial increase in imports from Mexico for processing within the United States (table 4). The United Kingdom (58%) and India and Switzerland (10% each) were the principal destinations for refined bullion exports (table 4).

Engelhard's daily price of gold was volatile and rose above the $1,400-per-troy-ounce level for the first time ever in November. The price began the year at $1,124.06 per troy ounce and fell to the year's lowest level of $1,060.45 per troy ounce on February 5. The price rose for 4 months before dropping in July. It recovered and continued to increase until peaking at $1,424.07 per troy ounce on November 9 before dropping to $1,414.25 per troy ounce by yearend. The annual average price of $1,227.51 per troy ounce, 26% above the annual average gold price in 2009, was the highest annual average price ever, and the ninth consecutive year of a price increase.

Gold investment continued to be very high in 2010 because of financial and economic uncertainties; such times are traditionally when investment in gold, which is considered to be a safe investment, increases. It was estimated that global investors purchased 1,680 metric tons (t) of gold in 2010. Gold held in 23 gold exchange-traded funds (ETFs) and 2 physically backed Canadian funds increased by 351 t to 2,190 t. Domestic gold holdings in ETFs increased by 19%, or 229 t, to 1,450 t, with the SPDR Gold Trust, which traded on the New York Stock Exchange, accounting for 88% of domestic gold ETF holdings. Because gold ETFs are essentially paper gold products, each share representing a physical allotment of gold that is held in trust, they provide an easily accessible investment. Gold ETFs follow market gold prices, with a fee structure to cover administrative and storage costs (Klapwijk and others, 2011, p. 20–26).

The top 15 gold mining companies produced about 47% of 2010 world gold production. The top five producers were, in descending order, Barrick, Newmont Mining Corp. (Denver, CO), AngloGold Ashanti Ltd. (Johannesburg, South Africa), Gold Fields Ltd. (Johannesburg), and Goldcorp Inc. (Vancouver, British Columbia, Canada), which accounted for almost one-third of world gold production (Klapwijk and others, 2011, p. 48).

In 2010, gold mining companies strove to increase their reserves by merging or acquiring other companies. Newcrest Mining Ltd. (Melbourne, Victoria, Australia) purchased Lihir Gold Ltd. (Port Moresby, Papua New Guinea), which owned the Lihr Island Mine in Papua New Guinea. Kinross Gold Corp. (Toronto) completed a merger with Red Back Mining Inc. (Vancouver), which owned the Chirano Gold Mine in Ghana and the Tasiast Gold Mine in Mauritania. In August, Goldcorp sold its San Dimas silver-gold mine in Mexico to Mala Noche Resources Corp. (Toronto), which was renamed Primero Mining Corp. (Toronto). Goldcorp also sold its 21% interest in the Morelos project in Mexico to Gleichen Resources Ltd. (Toronto), now named Torex Gold Resources Inc. (Toronto). Goldcorp acquired Andean Resources (Fremantle, Western Australia, Australia), which owned the Cerro Negro gold-silver project in Argentina. Thompson Creek Metals Co. Inc. (Vancouver) purchased Terrane Metals Corp. (Vancouver) after Goldcorp divested its controlling interest in the company. Terrane owned the Mt. Milligan copper-gold project in British Columbia, Canada. Anatolia Minerals Development Ltd. (Englewood, CO) and Avoca Resources Ltd. (Perth, Western Australia, Australia) announced plans to merge. The new company, Alacer Gold Corp. (Englewood, CO), would have mines in Australia and Turkey. Other announcements in 2010 were that EBX Group (Rio de Janeiro, Brazil) was going to take over Ventana Gold Corp. (Vancouver), which had the La Bodega project in Columbia, and Franco Nevada Corp.'s (Toronto) business combination with Gold Wheaton Gold Corp. (Vancouver) (Klapwijk and others, 2011, p. 48). In March, Barrick created African Barrick Gold plc (London, United Kingdom) to hold Barrick's African gold mines, projects, and exploration properties. As of April 2010, Barrick owned approximately 73.9% of African Barrick Gold (Barrick Gold Corp., 2011a, p. 36).

Total world mine production of gold in 2010 was 4% higher than that of 2009. Mine production in China increased, and China continued to be the world's leading gold producer. Annual output in South Africa decreased for the 10th year in a row because of higher costs, lower grade ore, and labor issues. The leading producers among more than 95 gold-mining nations were, in descending order, China, Australia, the United States, Russia, and South Africa (table 8).

An estimated 166,600 t of gold was mined historically through 2010, with 29,000 t held by central banks as official stocks, 31,100 t held privately as investment, 84,200 t held privately as jewelry, 18,700 t in other fabricated products, and the remaining 3,600 t was unaccounted for (Klapwijk and others, 2011, p. 58).

Production

Domestic lode mine production data for gold were compiled by the U.S. Geological Survey from two separate voluntary surveys of U.S. mining operations—one for monthly production of copper, gold, lead, silver, and zinc from lode mines and the other for lode mine production data surveyed annually. Individual company production and performance data listed in table 3 and cited elsewhere in this report were obtained from published sources, such as company annual reports.

Alaska.—Gold production was 28,100 kg which was valued at $1,110 million in 2010. According to the State's Division of Geology and Geophysical Surveys, 2009 gold production was reported as 24,300 kg (781,000 troy ounces) valued at $759 million. In 2010, placer gold mining accounted for 2,160 kg (69,300 troy ounces) of gold, up 15% from 1,870 kg (60,300 troy ounces) in 2009. An estimated 227 placers mines operated in 2010, 3% fewer than the 234 that operated in 2009. There were two placer operations that were classified as large placer operations, production of more than 78 kg (2,500 troy ounces) of gold, and 35 placer operations were classified as medium, production of more than 20 kg (650 troy ounces) but less than 78 kg (2,500 troy ounces) of gold, in 2010 (Szumigala and others, 2011, p. 13, 46).

The Pogo Mine, 145 kilometers (km) southeast of Fairbanks was a joint venture between Sumitomo Metal Mining Co. Ltd. (Tokyo, Japan) (85%) and Sumitomo Co. (Tokyo) (15%). The mine produced 11,900 kg of gold during 2010, which was a slight decrease as compared with that of 2009, because of lower ore grade. As of December 2010, the mine's reserves were 122 t of contained gold (Sumitomo Metal Mining Co. Ltd., 2011, p .19; Szumigala and others, 2011, p. 52).

Kinross's underground Fort Knox Mine, near Fairbanks, produced 10,900 kg of gold in 2010, 33% more than production in 2009. Increased production resulted from the first full year of production from the Walter Creek heap-leach facility, which was completed in November 2009. Gold reserves at Fort Knox were estimated to be about 180 t at yearend 2010 (Kinross Gold Corp., 2011, p. 31, 48; Szumigala and others, 2011, p. 51).

Hecla Mining Co. (Coeur d'Alene, ID) owned one of the leading silver mines in the country, the polymetallic Greens Creek Mine on Admiralty Island near Juneau. The ore from the underground mine was milled at the mine site, and the smelter produced gold and silver dore, lead, zinc, and bulk concentrates. In 2010, gold production was 2,140 kg, slightly more than 2009 gold production (Hecla Mining Co., 2011, p. 3, 10).

On June 24, Coeur d'Alene Mines Corp.'s (Coeur d'Alene, ID) Kensington project began processing ore, and on July 3, the mine began commercial production and produced 1,340 kg of gold in 2010. The underground gold mine, 72 km north-northwest of Juneau, had proven and probable reserves of 43,900 kg of gold (Coeur d'Alene Mines Corp., 2011, p. 2, 26).

Fire River Gold Corp. (Vancouver) continued evaluating the Nixon Fork Mine, 56 km northeast of McGrath. The company planned to bring the mine back into production by the summer of 2011. The mine originally started production in 2007; however, production was suspended in October 2008, and the mine was placed on care-and-maintenance status because of dramatically lower grade ore than expected and sold to Fire River Gold in 2009 (Fire River Gold Corp., 2011, p. 3–8).

Alaskan exploration expenditures climbed to $264 million in 2010, up 47% from 2009 expenditures of $180 million. This marked the sixth straight year with exploration expenditures more than $100 million. In 2010, 34 projects had expenditures of more than $1 million, and an additional 47 projects spent $100,000 or more on exploration. Porphyry copper deposits accounted for 38% of the exploration expenditures and other intrusion-related deposits accounted for 36% (Szumigala and others, 2011, p. 9, 12).

Anglo American plc (London) and Northern Dynasty Minerals Ltd. (Vancouver) were 50-50 partners in the Pebble copper-gold-molybdenum project in southwestern Alaska, which included the high-grade underground Pebble East resources and the open pit Pebble West resources. Based on its $73 million budget, the project remained the leading exploration project in Alaska. A preliminary assessment report based on concept, prefeasibility, and feasibility-level study programs was completed with three potential mining scenarios—[25, 45, and 78 years of open pit mining, with a nominal processing rate of 200,000 metric tons per day (t/d) of ore]. The company was expected to use the 25-year case study to decide whether to initiate mine permitting, construction, and operation. The 45-year reference case was the base case and would produce 14 million metric tons (Mt) of copper, 635,000 t of molybdenum, 4,350 t of silver, 1,200 t of rhenium, 933 t of gold, and 28 t of palladium while mining only 32% of the mineral resources at an average cost of $0.11 per pound of copper. The resource case, which was based on the 78-year mine life, assessed the long-term value of the project. A new prefeasibility study was expected to be completed in 2012, with production by the end of 2016 (Northern Dynasty Minerals Ltd., 2011, p. 5–7).

In 2010, a feasibility study was revised by Barrick and NovaGold Resources Inc. (Vancouver) on the Donlin Creek joint venture in the historic Kuskokwim Gold Belt in southwestern Alaska with the addition of an evaluation of a natural gas pipeline for the project. The project had a measured and indicated gold resource of 1,200 t, and the companies were scheduled to file permit applications by the end of 2011 (Barrick Gold Corp., 2011a, p. 11, 168).

NovaGold was developing three other projects in Alaska—Big Hurrah, Nome Gold, and Rock Creek—all near Nome on the Seward Peninsula. The most advanced was the Rock Creek Mine, which was designed to produce about 3,000 kilograms per year (kg/yr) of gold. The mine and mill began production in 2008 but operated only a short time before the mine was placed on care-and-maintenance status. NovaGold decided to sell all three operations and focus on its joint ventures, Donlin Creek in Alaska and Galore Creek in British Columbia, Canada (NovaGold Resources Inc., 2011, p. 40). NovaGold completed its purchase of the Ambler property from Kennecott Exploration Co. (Vancouver) for $29 million. The property includes the copper-zinc-gold-silver Arctic volcanogenic massive sulfide (Szumigala and others, 2011, p. 15).

International Tower Hill Mines Ltd. (Vancouver) continued to explore its Livengood project in 2010. The indicated resource was 409 t at a grade of 0.83 grams per metric ton (g/t) gold equivalent to 339 t of contained gold, and the inferred resource was 94 t at a grade of 0.79 g/t gold equivalent to 75 t of contained gold, both at a cutoff grade of 0.5 g/t gold. The project, 110 km north of Fairbanks, was undergoing prefeasibility study in 2010 (International Tower Hill Mines Ltd., 2010).

Arizona.—In 2010, all gold mined in Arizona was recovered as a byproduct from copper mining and processing. American Bonanza Gold Corp. (Vancouver) completed a feasibility study and purchased a mill for its Copperstone underground gold project in La Paz County. In October, the U.S. Department of the Interior, Bureau of Land Management (BLM) issued the Federal permits for mining, and the outstanding State of Arizona permits were expected to be completed in the first quarter of 2011 (American Bonanza Gold Corp., 2011, p. 3–4).

California.—In 2010, gold was produced at Atna Resources Ltd.'s (Golden, CO) Briggs Mine and New Gold Inc.'s (Vancouver) Mesquite Mine. Other operations produced gold as a secondary product, mainly from placer sand and gravel mines and from several small underground mines that produced primarily specimen gold products.

In 2010, the Mesquite Mine open pit in Imperial County, CA, 70 km northwest of Yuma, AZ, produced 5,260 kg of gold, 13% more than that produced in 2009. Production increases resulted from increases in gold grade and leach pad recoveries. The proven and probable reserves for Mesquite were estimated to be 169 Mt at a grade of 0.57 g/t, with 97,000 kg of contained gold (New Gold Inc., 2011a, p. 10; b).

In May 2009, Atna poured its first bar of gold from the Briggs Mine, and in 2010, the mine produced 784 kg of gold. An updated technical report on the Briggs Mine estimated the proven and probable reserves to be 6,250 kg of gold (Atna Resources Ltd., 2011, p. 2–4).

Sutter Gold Mining Inc. (Lakewood, CO) received regulatory approval to construct the Sutter Gold underground mine, which included the historic Lincoln gold mine along California's Mother Lode belt. The company expected to complete preliminary economic assessment and technical reports by the first quarter of 2011 (Sutter Gold Mining Inc., 2011, p. 2–3).

Emgold Mining Corp. (Vancouver) continued the permitting process to reopen the historic Idaho-Maryland Gold Mine. The company expected to have the final environmental impact report in 2011. The estimated measured and indicated resources were 14,700 kg of gold (Emgold Mining Corp., 2011).

Colorado.—In 2010, Colorado remained the fourth ranked gold-producing State in the country. The Nation's ninth ranked gold mine, the Cresson Mine, owned by Cripple Creek & Victor Gold Mining Co. (CC&V) (a fully owned subsidiary of AngloGold) reported that its open pit operation produced 7,250 kg of gold in 2010, a 7% increase from that in 2009 owing to a revised pad-stacking strategy, which saw higher grade ore placed closer to the pad lining to improve production. In 2010, CC&V continued construction of a mine-life extension project that would add 4 years to the mine life (AngloGold Ashanti Ltd., 2011, p. 45, 54, 110–111).

Global Minerals, Ltd. (Vancouver) sold its shares of the Front Range gold property, which included the Cash and Rex Mines, to Aurora Gold Corp. (Zug, Switzerland) in August. Aurora intended to reopen the Cash Mine, which had been inactive since 2008 (Aurora Gold Corp., 2010).

LKA International Inc.'s (Gig Harbor, WA) Golden Wonder Mine in the San Juan Mountains stopped commercial gold production in the second quarter of 2006. The company continued to explore and produced a limited amount of gold in 2010 as a result of exploration activities (LKA International, Inc., 2010).

Idaho.—Idaho had limited gold production in 2010, mostly from small-scale mines and byproduct production from silver mines. Several companies had projects with associated gold that were in early development stages in 2010.

Montana.—There was no gold production in the State in 2010 because Elkhorn Goldfields LLC's (Denver) open pit polymetallic Montana Tunnels Mine near Jefferson City had not operated since April 2009 when the mine was placed on care-and-maintenance status. In early February, Elkhorn completed the acquisition of the remaining 50% interest in the project from Apollo Gold Corp. (Greenwood Village, CO) (Elkhorn Goldfields LLC, 2011). Also, Barrick's Golden Sunlight Mine did not produce gold in 2010 because the mine had entered an extended redevelopment phase in 2009 and was not expected to produce gold again until 2011 (Barrick Gold Corp., 2011a, p. 64).

Nevada.—Gold production increased 3% to 166,000 kg in 2010, and Nevada kept its long-standing position as the Nation's leading gold-producing State. Gold remained the most valuable mine product in Nevada, representing almost 89% of gross proceeds of mines. The Nevada Division of Minerals reported 20 major gold-silver operations (Dobra, 2011, p. 4).

In 2010, Barrick produced 89,200 kg of gold from its fully owned Bald Mountain, Cortez, Goldstrike, Ruby Hill, and Storm Mines; its 75% share of the Turquoise Ridge Mine (a joint venture with Newmont, 25%); 50% of Smoky Valley Common Operation (50% owned and operated by Kinross); and 33.33% of the Marigold Mine (67.67% owned and operated by Goldcorp). This was 14% more than the company's gold mine production from Nevada in 2009 because of the startup of production at Cortez Hill open pit operations, which was part of the Cortez operations, in the first quarter of 2010. The Cortez operations produced 35,500 kg of gold in 2010, 120% higher than production in 2009. Production at all other Barrick operations decreased in 2010 compared with that of 2009. Open pit and underground production from Goldstrike (including the Storm Mine) was 38,600 kg of gold, a 13% decrease compared with that in 2009. The decrease was attributed to the partial shutdown of the autoclaves in the second half of 2009 and as well as mining lower grade areas in the first half of 2010. Production from Bald Mountain was 1,800 kg, 23% less than production in 2009 owing to the approval of the mining expansion plan that called for more waste material mining in 2010. Production was expected to increase once the expansion was completed in late 2011. In 2010, the Ruby Hill Mine produced 2,530 kg of gold or 21% less than that in 2009, because of higher waste stripping. Production of gold in 2010 from partially owned mines was 10,800 kg, 11% less than that of 2009. In 2010, Barrick's share of gold production from the Marigold Mine was 1,420 kg (a 7% decrease compared with 2009 gold production), 5,540 kg from the Smoky Valley Common Operation (a decrease of 15% from 2009 production), and 3,860 kg from Turquoise Ridge (a decrease of 7% from 2009 production) (Barrick Gold Corp., 2011a, p. 24, 63–64; 2011b).

Newmont's Nevada operations produced 55,000 kg or 33% of Nevada's gold production from eight open pits and six underground mines. The operations were the Eastern Nevada Operations (Carlin East, Gold Quarry, Leeville, North Lantern, and Pete Mines) and the Lone Tree, Midas, Mule Canyon, Phoenix, Trenton Canyon, Twin Creeks, and the joint-venture Turquoise Ridge (25% share) Mines. In 2010, gold production from Newmont's Nevada operations decreased by 13% because of less ore mined from Gold Quarry, less ore placed on leach pads at Twin Creeks and Carlin, and completion of mining at Deep Post. The losses were partially offset by increased mining at Leeville Mine. As of December 31, the company reported 970,000 kg of gold reserves of which 81% was in open pit mines and the remainder was in underground mines (Newmont Mining Corp., 2011, p. 23–24, 59).

In 2010, Great Basin Gold Ltd. (Vancouver) extracted 98,800 t of ore, yielding 3,270 kg of gold and 8,990 kg of silver from trial mining activities at the underground Hollister Mine. A preliminary draft environmental impact statement (EIS) was scheduled for completion in November 2011, and the decision on whether to proceed with the project was scheduled in early 2012 (Great Basin Gold Ltd., 2011, p. 11–14).

In 2010, Yukon-Nevada Gold Corp. (Vancouver) produced 2,030 kg of gold from purchased ore and stockpiles, at its Jerritt Canyon complex. The operations consisted of a milling facility and two underground mines, Smith and SSX. Jerritt Canyon was closed in 2009 because of environmental permitting problems but was restarted in 2010 (Yukon-Nevada Gold Corp., 2011, p. 1).

In 2010, the Robinson copper mine near Nye [owned by Quadra Mining Ltd. (Vancouver)] produced 49,400 t of copper and 2,270 kg of gold. Production was lower than that in 2009 because of anticipated lower head grades (Quadra Mining Ltd., 2011, p. 8).

The Rochester Mine, owned by Coeur d'Alene Mines, produced 62,200 kg of silver and 300 kg of gold. In August 2007, the company completed mining existing reserves; however, gold and silver production was expected to continue from stockpiled ore and existing leach pads until 2014. The company completed a feasibility study regarding restart of mining operations from expanded and new reserves. The mine was expected to increase production to 74,600 kilograms per year (kg/yr) of silver and 1,080 kg/yr of gold. In October, the company received a permitting decision from the BLM supporting the resumption of mining. Mining was planned to resume in the first quarter of 2011 (Coeur d'Alene Mines Corp., 2011, p. 2–3).

Rio Tinto plc (London) sold the Denton-Rawhide Mine to Rawhide Acquisition Holdings on June 25. Rio Tinto's share of production was 280 kg in 2010. Mine production stopped in 2003, but residual production from leach pads continued (Rio Tinto plc, 2011a, p. 12–14).

Exploration expenditures in Nevada increased to $214 million in 2010 from $110 million in 2009, the highest expenditures reported since the State began the survey in the mid-1990s. Because of higher gold and silver prices, material once classified as waste has been reclassified as ore, and reported proven and probable reserves have increased. According to the State of Nevada, the proven and probable gold reserves increased to 2,500 kg (80 million troy ounces) in 2010, up 7% from 2,300 kg (75 million troy ounces) in 2009 (Dobra, 2011, p. 5).

New Mexico.—Gold production in New Mexico has been a byproduct of copper production in Grant County at Freeport-McMoRan Copper & Gold Inc.'s Chino Mine. In late 2008, mining activities were suspended, and in 2010, there was no significant gold production. Mining and milling were expected to resume in 2011 (Freeport-McMoRan Copper & Gold Inc., 2011, p. 37).

In 2010, one silver and gold project began development, and several polymetallic deposits were explored. In March, Santa Fe Gold Corp. (Albuquerque) began limited production at the Summit silver and gold mine and anticipated that full production would be reached by yearend 2011. Full production was estimated to be 120,000 metric tons per year of ore at a grade of 4.45 g/t gold and 335 g/t silver (Santa Fe Gold Corp., 2010).

South Carolina.—Romarco Minerals Inc. (Vancouver) released the results of a feasibility study for its Haile Gold Mine Project in Lancaster County. The estimated proven and probable reserves were 30.5 Mt of ore at an average grade of 2.06 g/t gold, containing 62,800 kg of gold. The mine life was estimated to be 13 years, and during the first 5 years, annual production was estimated to be 5,350 kg of gold at a cost of $347 per troy ounce (Romarco Minerals Inc., 2011, p. 14, 21).

South Dakota.—In 2010, Wharf Resources (USA) Inc. (Lead) operated the Goldcorp-owned Wharf open pit gold mine near Lead, which produced about 2,280 kg of gold, 8% more than 2009 gold production. The increase was attributed to an increase in ore processed and higher recovery rates, which offset the drop in head grade (Goldcorp Inc., 2011, p. 58).

Utah.—Rio Tinto's Bingham Canyon Mine near Salt Lake City, which was operated by Kennecott Utah Copper Corp. (Magna), produced 14,500 kg of gold as a byproduct from copper mining. Bingham Canyon was the fourth-ranked gold producer and the leading gold-producing mine outside Nevada in 2010. Gold production decreased by 20% compared with that in 2009 because of lower ore grades, as the company shifted from a high copper-gold area to high-molybdenum areas of the ore body. Kennecott Utah was also commencing studies associated with the potential development of an underground copper skarn deposit to operate in parallel with the open pit. In 2010, Kennecott Utah also operated the nearby Barney's Canyon Mine, which closed in the first quarter of 2002 but continued gold production from heap-leaching pads that produced 62 kg of gold (Rio Tinto plc, 2011a, p. 12; b, p. 18).

Washington.—In 2010, Kinross's underground Kettle River-Buckhorn Mine in the north-central part of the State produced 6,180 kg of gold, 15% more than production in 2009 because of increased ore processing. Ore was shipped to the Kettle River Mill adjacent to the closed Kettle River Mine, which was about 76 km from the Kettle River-Buckhorn Mine (Kinross Gold Corp., 2011, p. 50–51).

World Industry Structure

World gold mine production in 2010 was 4% higher than that in 2009, and it was the second year in a row that world production increased (table 8). Some of the larger increases in gold production were 37,000 kg in Australia; 25,000 kg in China; 21,200 kg in Mexico; 13,400 kg in Argentina; 11,500 kg in Burkina Faso; 8,000 kg in Ethiopia; 7,920 kg in the United States; 7,400 kg in Kazakhstan; 5,770 kg in Colombia; 4,030 kg in Zimbabwe; and 3,800 kg in the Philippines. In 2010, gold production in 21 countries increased by more than 1 t from production in 2009.

These increases were partially offset by gold production decreases in several countries. Some of the larger decreases in gold production in 2010 were 18,300 kg in Peru; 10,000 kg in Indonesia; 8,930 kg in South Africa; 6,340 kg in Canada; 5,360 kg in Mali; and 3,770 kg in Mongolia. In 2010, production of gold decreased by more than 1 t in 9 countries.

The 12 leading gold producing-countries—China, Australia, the United States, Russia, South Africa, Peru, Indonesia, Canada, Uzbekistan, Ghana, Mexico, and Papua New Guinea (in descending order) accounted for 74% of global production. The next 10 leading gold-producing countries accounted for 16%, while the remaining 77 countries made up 10% of global gold production in 2010.

According to its annual review of world gold supply and demand, Gold Fields Mineral Services Ltd. (GFMS) calculated that the total global supply of gold in 2010 was 4,330 t compared with the revised 2009 total supply of 4,320 t. GFMS reported increased mine production (4%), no net official sector sales, no net producer hedging, and no implied net disinvestment for sales of bars and coins by private investors. Old scrap production decreased slightly in 2010 compared with 2009 old scrap production because consumers expecting higher gold prices deferred selling scrap during the year (Klapwijk and others, 2011, p. 7).

GFMS reported that total fabrication in 2010, including the use of scrap, was 2,780 t, 11% higher than that of 2009. In 2010, gold jewelry fabrication was 2,020 t, 11% higher than that of 2009. The top six gold jewelry manufacturing countries—India (685 t), China (432 t), Italy (116 t), Turkey (73 t), the United States (66 t), and Saudi Arabia (47 t)—represented 70% of the world's jewelry production. In 2010, jewelry production in India increased by 181 t, 36% more than 2009 production, because of a surge in demand for gold jewelry. Chinese jewelry production increased by 68.7 t, 19% more than 2009 production. In the Middle East, Southeast Asia (excluding China), and Italy, jewelry production in 2010 decreased owing to increased gold prices. Jewelry consumption in India and China increased, by 40% and 20%, respectively. These increases were offset by consumption decreases in Italy, the United States, and Saudi Arabia, which decreased by 16%, 14%, and 13%, respectively. Coin fabrication was 207 t, a decrease of 9% compared with that of 2009, because of lower sales in North America and Europe. The demand for safe-haven investments kept gold coin sales high, but sales of new silver coins supplanted some gold coin sales. In 2010, the U.S. Mint sales of the American Eagle gold coins were 38,000 kg, which was 14% lower than the unusually high sales in 2009, and sales of the American Buffalo coins were 6,500 kg, an increase of 5% compared with those in 2009. In 2010, Canada decreased gold coin minting to 29,900 kg, a decrease of 22% compared with minting in 2009, and Austria minted 21,700 kg, an increase of 35%. The amount of gold used in electronics increased by 19% to 327 t, which reflected the global economic recovery. Gold used in dentistry declined by 8% to 49 t in 2010 owing to an increase in nonmetallic substitutions. Gold used in other industrial and decorative applications increased by 11% because of an increase of consumption in China. Gold used in medals and for imitation coins (nonmonetary coins) increased by 50% because of increased consumption in India (Klapwijk and others, 2011, p. 35–37, 83–109).

World Review

Argentina.—In 2010, gold production was 60,000 kg or 29% more than that in 2009, primarily because production from Barrick's Veladero Mine increased by 83% to 34,900 kg because of higher ore grades and increased throughput as a result of expanded crushing capacity (Barrick Gold Corp., 2011a, p. 14; b).

In 2010, production from AngloGold's Cerro Vanguardia Mine was 6,490 kg of gold, a slight increase compared with production in 2009 (AngloGold Ashanti Ltd., 2011, p. 112–113). Overall production increases were partially offset by production losses at Yamana Gold Inc.'s (Toronto) Gualcamayo Mine, which produced 4,200 kg of gold during the year, 6% lower than that in 2009. In 2010, gold production from Bajo de la Alumbrera Mine [owned by Xstrata plc (Zug, Switzerland) (50%), Goldcorp (37.5%), Yacimientos Mineros Agua de Dionisio (Catamarca) (20%), and Yamana (12.5%)] was 12,600 kg, 4% lower than production in 2009 (Yamana Gold Inc., 2011, p. 52–56).

Australia.—Australian gold production in 2010 increased by 17% compared with that in 2009. Production increases were from new projects coming online during the year, established operations, and increases from mines that began operation in 2009. In 2010, 10 mines started or restarted production—A1 Minerals Ltd.'s (Osborne Park, Western Australia) Brightstar Mine, which started production in the first quarter; Catalpa Resources Ltd.'s (Perth) Edna May Mine, which started production in the second quarter; Exco Resources Ltd.'s (Perth) and Poymetals Mining Ltd.'s (Samford, Queesland) White Dam Mine, which poured its first gold in April; GBM Gold Ltd.'s (Bendigo, Victoria) Inglewood Mine, which started production in the second quarter; Intergra Mining Ltd.'s (Perth) Aldiss-Randalls Mine, which started up in September; La Mancha Resources Inc.'s (Montreal, Quebec, Canada) White Foil Mine, which began production in the second quarter; Navigator Resources Ltd.'s (Perth) Bronzewing Mine, which began production in April; Range River Gold Ltd.'s (Melbourne) Mt. Morgans Mine, which started production in the first quarter; Regis Resources Ltd.'s (Perth) Duketon project, which began production in September; and Saracen Minerals Holdings Ltd.'s (Melbourne) South Laverton Region Mine, which began production in the first quarter (CPM Group, 2011, p. 86–88).

In 2010, Barrick had six mines in Australia, from which Barrick's share of production was 44,200 kg of gold, slightly more than that in 2009. All mines except the Kalgoorlie Mine, were fully owned by Barrick. In 2010, Cowal production was 28% higher than production in 2009 because of higher ore grade. Production from Kalgoorlie, a joint venture with Newmont, increased by 14% in 2010 compared with production in 2009 owing to an increase in overall ore grade and increased mill throughput. Production increases were partially offset by production decrease at several mines because of lower ore grade and lower mill throughput. The Barrick mines that produced less gold in 2010 compared with 2009 production were—Osborne, 37% less; Kanowna, 12% less; and Plutonic, 6% less; and Yilgran South 3% less. Osborne ceased mining in July 2010 (Barrick Gold Corp., 2011a, p. 66; b).

Newmont's Boddington Mine began into commercial production in November 2009 and ramped up production to 22,600 kg of gold and 26,300 t of copper in 2010. As of December 2010, the company reported reserves of 631,000 kg of gold and 1,070,000 t of copper. Newmont also owned the Jundee and Tanami operations as well as the Kalgoorlie joint-venture project with Barrick. The Jundee operation sold 10,400 kg of gold in 2010, 18% more than that in 2009. Tanami sold 7,780 kg of gold, 13% less than that in 2009. Newmont also owned a 16.22% interest in Regis, which owned the Duketon gold project. Duketon began production in the third quarter of 2010 and produced 156 kg of attributable gold. As of December 31, Newmont reported 9,330 kg of gold reserves in properties in Australia (Newmont Mining Corp., 2011, p. 26, 61–62).

In 2010, Newcrest operated five mines in Australia. The Cadia Hill and Ridgeway Mines produced 13,600 kg of gold, an 18% increase compared with 2009 production because of higher ore grade and increased throughput. The Telfer Mine produced 21,200 kg of gold in 2010, slightly more than production in 2009. The 70%-owned Cracow and the 100%-owned Mt. Rawdon Mines produced 3% and slightly less gold, respectively, compared with production in 2009 (Newcrest Mining Ltd., 2011).

Gold Fields produced gold from two mines in Australia—Agnew and St. Ives. In 2010, Agnew produced 4,730 kg of gold, 19% less than that produced in 2009 owing to restricted underground access to higher grade areas. St. Ives produced 14,600 kg of gold in 2009, 13% more than 2009 production, because of increased mining and higher ore grade. Production in 2011 was expected to increase as new pits came online (Gold Fields Ltd., 2011, p. 55, 92–95).

In 2010, AngloGold's Sunrise Dam Mine produced 12,300 kg of gold, a slight decrease compared with 2009 gold production. The mine consisted of an open pit and an underground mine (AngloGold Ashanti Ltd., 2011, p. 105–107).

OZ Minerals Ltd. (Melbourne) produced concentrates from its Prominent Hill copper mine, and during 2010, the mine produced 112,000 t of copper and 6,110 kg of gold. The company produced 160% more gold than in 2009 because the mine had its first full year of production in 2010 (OZ Minerals Ltd., 2011, p. 12).

Azerbaijan.—All gold production came from Anglo Asian Mining plc's (London) Gedabek Mine, which started production in the second quarter of 2009, and produced 1,900 kg of gold in 2010 (Anglo Asian Mining plc, 2011).

Botswana.—Production in 2010 increased by 20% because of production increases at the country's only primary gold mine. In 2010, IAMGOLD Corp.'s (Toronto) Mupane Mine produced 1,770 kg of gold, 12% greater than 2009 production because of higher throughput and improved performance from the ball mill (IAMGOLD Corp., 2011, p. 42, 44).

Brazil.—In 2010, Brazilian gold production increased by 3% compared with that in 2009 owing to increased production from the Kinross's Paracatu Mine in the State of Minas Gerais. The 36% increase in production to 15,000 kg was largely owing to increases in ore grade, higher recovery factors, and increased ore processing (Kinross Gold Corp., 2011, p. 54–55).

Production from AngloGold's Mineração Mine was 10,500 kg of gold or 3% more than that in 2009. Ore was produced from the Cuiaba and Lamego underground mines, leached at the Córrego do Sitio heap-leach operations, and then processed at the Cuiaba and Queiroz plants. The increased production was attributed to additional ore supplies resulting from the startup of the Lamego project. The Serra Grande (a joint venture equally owned by AngloGold and Kinross) produced 4,820 kg of gold, a slight increase compared with that in 2009. The operation, in central Brazil, consists of three underground mines (Mina III, Mina Nova, and Palmeiras) and an open pit mine (Mina III) (AngloGold Ashanti Ltd., 2011, p. 55, 116, 118–119).

Yamana operated three mines that produced gold in 2010. The Chapada Mine produced 4,220 kg of gold, a 13% decrease compared with 2009 production because of lower ore grades despite increased ore mining and processing. The Jacobina complex of underground mines in the State of Bahia produced 3,800 kg of gold, an 11% increase compared with production in 2009. The increase resulted from increased recovery rates. The Fazenda Brasileiro Mine, an underground mine in northeastern Brazil, produced 2,180 kg of gold, 8% lower than that in 2009. Two other mines owned by Yamana in Brazil—São Vicente and São Francisco—were part of an agreement to be sold to Aura Minerals Inc. (Vancouver) that was finalized on April 30 (Yamana Gold Inc., 2011, p. 49–56).

Jaguar Mining Inc. (Concord, NH) operated three mines in 2010 and produced 4,290 kg of gold, 8% less than 2009 production. The Turmalina Mine produced 1,850 kg of gold and the Paciencia Mine produced 1,840 kg of gold in 2010. Production decreased because of technical problems at Turmalina and decreased ore grade at both mines. These decreases were partially offset by new production from the Caeté Mine, which began gold production in the third quarter of 2010 (Jaguar Mining Inc., 2011, p. 9–12).

Bulgaria.—Gold production in 2010 was estimated to be 3,500 kg, 22% less than in 2009. Losses at the Dundee Precious Metals Inc.'s (Toronto) Chelopech Mine were the main reason for the drop in production. In 2010, the mine produced 2,040 kg of gold, 26% less than 2009 production because of lower gold grades (Dundee Precious Metals Inc., 2011, p. 34).

Burkina Faso.—In 2010, gold production was 25,000 kg, an 85% increase compared with 2009. The increase was partially attributed to the start up of IAMGOLD's 90%-owned Essakane Mine. The mine, which started production in July, produced 3,790 kg of gold in 2010 (IAMGOLD Corp., 2011, p. 15).

The increase was also partially attributed to a 17% increase in gold production from SEMAFO Inc.'s (Saint-Laurent, Quebec, Canada) Mana Mine that produced 5,590 kg of gold in 2010. Production increased because of a plant expansion program, which increased the mine's processing capacity from 4,000 to 6,000 t/d (SEMAFO Inc., 2011, p. 12).

Canada.—Canada ranked eighth in world gold production, and its output decreased by 7% to 91,000 kg. Goldcorp operated three mines in Ontario—the Musselwhite, Porcupine, and Red Lake Mines. In 2010, the Red Lake Mine produced 21,900 kg of gold, a 13% increase compared with 2009 production because of a significant increase in tonnage mined. The Porcupine Mine produced 8,270 kg, which was 16% less than in 2009, because of lower ore grade, and the Musselwhite Mine produced 8,050 kg of gold or 11% more than production in 2009 because of higher ore throughput (Goldcorp Inc., 2011, p. 45–47).

Agnico-Eagle Mines Ltd. (Toronto) operated the Goldex, Lapa, and LaRonde Mines in Quebec. In March, the company opened the Meadowbank Mine in Nunavut Territory, which produced 8,260 kg of gold during the year. In 2010, the LaRonde Mine produced 4,220 t of copper, 5,060 kg of gold, 111,000 kg of silver, and 62,500 t of zinc. Gold production from LaRonde Mine was 25% less in 2010 compared with 2009 because processing lower grade ore became economical with higher gold and zinc prices. In 2010, the Goldex Mine produced 5,740 kg of gold, 19% more than 2009 production because of ongoing mill upgrades. Agnico-Eagle's gold production was 45% higher in 2010 than that in 2009 owing to the startup of the Meadowbank Mine and the first full year of production from the Lapa Mine of 3,650 kg of gold (Agnico-Eagle Mines Ltd., 2011, p. 5–6, 8–11, 13).

Barrick owned and operated the Hemlo Mine and produced 7,530 kg of gold in 2010 compared with 8,550 kg in 2009. The drop in production was attributed to the processing of lower grade ore (Barrick Gold Corp., 2011a, p. 64; b).

Mine production in 2010 was lower at NorthGate Minerals Corp.'s (Vancouver) Kemess South Mine in British Columbia and Vale S.A.'s (Rio de Janeiro, Brazil) Sudbury nickel operations in Ontario. Gold production from the Kemess South Mine was 3,130 kg, 72% less than production in 2009 because the mine was nearing the end of its mine life (Northgate Minerals Corp., 2011). Vale's Sudbury operations produced 1,310 kg of gold, which was 17% less than 2009 production because of a labor strike which started in July 2009 (Vale S.A., 2011, p. 35, 44). IAMGOLD's Doyon Division produced 1,030 kg of gold in 2010, down by 69% compared with 2009 production because of the closure of the Doyon Mine in December 2009 and reduced production from Mouska Mine as it neared its end of life (IAMGOLD Corp., 2011, p. 42, 44). In 2010, Aurizon Mines Ltd. (Vancouver) produced 4,290 kg of gold, 13% less than 2009 gold production from its Casa Berardi Mine in Quebec (Aurizon Mines Ltd., 2011, p. 25). Westdome Gold Mines Ltd. (Toronto) owned the Eagle River Mine in Ontario and the Kiena Mine Complex in Quebec. In 2010, the Eagle River Mine produced 1,140 kg of gold, 65% lower than in 2009. The Kiena Mine Complex produced 1,000 kg of gold in 2010, 10% lower than 2009 production (Westdome Gold Mines Ltd., 2011, p. 6).

St Andrew Goldfields Ltd.'s (Toronto) Hislop Mine began production in June 2010 and produced 342 kg of gold during the year. The company's Holloway Mine, in Ontario, produced 1,790 kg of gold, 67% more than 2009 production because it was the first full year of production (St Andrew Goldfields Ltd., 2011, p. 7–11). Brigus Gold Corp. (Halifax, Nova Scotia), formerly Apollo Gold Corp., produced 2,170 kg of gold at its Black Fox Mine in Ontario, which was 34% greater than 2009 production (Brigus Gold Corp., 2011, p. 6).

Chile.—In 2010, gold production was 38,400 kg, 6% less than that in 2009. The production losses were attributed to reduced production from Kinross's Maricinga Mine because of longer leach times. In 2010, the mine produced 4,960 kg of gold, 32% less than in 2009. Kinross's other mine in Chile, La Coipa, produced 6,110 kg of gold in 2010, 15% less compared with 2009 because lower grade ore was processed (Kinross Gold Corp., 2011, p. 55–59).

The country's leading gold-producing mine was Yamana Gold's El Penon Mine, which produced 7,980 kg of gold, 19% more than in 2009 because of increased tonnage processed, higher recovery rates, and increased gold grade. Yamana also produced 2,940 kg of gold from Minera Florida, 15% more than that in 2009 because an expansion was completed (Yamana Gold Inc., 2011, p. 51, 54).

China.—China's gold production increased by 8% to 345,000 kg, compared with 2009 gold production. The increase in gold production resulted from consolidation of smaller inefficient gold mines into larger more efficient gold mines and increases in mining because of higher gold prices, the low cost of labor, and support from the central government.

In 2010, Zijin Mining Group Co., Ltd. (Zijin, Guangdong Province) was the leading gold producer with more than 69,100 kg of gold production, including 29,200 kg of its own mine-produced gold and 39,900 kg of gold refined from third party ores. Production was 8% lower in 2010 than in 2009 because of heavy rains, flooding, and a tailings dam collapse (Zijin Mining Group Co., Ltd., 2011, p. 8).

In 2010, Eldorado Gold Corp. (Vancouver) fully integrated the three gold mines, two gold projects, and several exploration projects in China that the company acquired from its merger with Sino Gold Mining in 2009. The Jinfeng, Tanjianshan, and White Mountain Mines produced 11,100 kg of gold in 2010, which was 13% more than production in 2009. In 2010, Jinfeng was the second leading gold mine in China and produced 5,630 kg of gold. Tanjianshan and White Mountain Mines produced 3,540 kg and 1,930 kg of gold, respectively (Eldorado Gold Corp., 2011, p. 8, 10–12).

Colombia.—In 2010, gold production increased by 12% compared with that in 2009. A substantial portion of the increase came from small-scale mines. Mineros SA (El Bagre), the leading producer of gold, increased output by 10% because commissioning of the Ye Mine and increased production from dredging operations. These increases were partly offset by the suspension of mining at Gran Colombia Gold Corp.'s (Toronto) Frontino Mine (Klapwijk and others, 2011, p. 44).

Côte d'Ivoire.—In 2010, production of gold was 5,800 kg, 13% less than in 2009, because of production declines at Newcrest's Bonikro Mine. In 2010, the mine produced 2,920 kg of gold, 37% less than 2009 production (Newcrest Mining Ltd., 2011). In 2010, Cluff Gold plc (London) produced 629 kg of gold from its 90%-owned Angovia Mine. The mine produced 7% less gold in 2010 than that in 2009 because of the deteriorating political environment as well as operational challenges in the second half of 2010 (Cluff Gold plc, 2011, p. 20).

Randgold Resources Ltd. (London) started production from its Tongon Mine in the fourth quarter of 2010. The mine produced 875 kg of gold during the year and was projected to produce 8,000 kg in 2011 (Randgold Resources Ltd., 2011, p. 26–29).

Dominican Republic.—GlobeStar Mining Corp. (Toronto), a fully owned subsidiary of Perilya Ltd. (Leederville, Western Australia, Australia), produced 494 kg of gold in 2010 at its Cerro de Maimon copper-silver-gold mine, 32% more than production in 2009 (Perilya Ltd., 2011, p. 4). Construction of the Barrick (60%) and Goldcorp (40%) jointly owned Pueblo Viejo project continued in 2010, and the mine was scheduled to start producing in the first quarter of 2012. The project could produce an average of 29,000 kg/yr of gold during the first 5 years of operation (Barrick Gold Corp., 2011a, p 20, 41).

Egypt.— In 2010, gold production was 2,590 kg, up from 60 kg in 2009. All of the production came from Centamin Egypt Ltd.'s (Mt. Pleasant, Western Australia, Australia) Sukari Gold Mine, in the eastern desert of Egypt (Centamin Egypt Ltd., 2011).

Ethiopia.—Sharp increases in gold prices led to additional small-scale and artisanal mining operations in Ethiopia. In 2010, production was estimated to have reached 12,000 kg, up 200% from 2009 production. Almost all of the mine production came from artisanal, placer, and small scale-mining. Ethiopia currently has only one large-scale gold mine, MIDROC Gold Mine plc's (Addis Ababa) Lega Dembi Mine; gold production at the open pit and underground mine was estimated to be 3,750 kg, in 2010 (Klapwijk and others, 2011, p. 44).

Finland.—In 2010, Agnico-Eagle had its first full year of production from the Kittlia Mine in northern Finland. The mine produced 3,930 kg of gold in 2010, which was 41% more than 2009 production of 2,300 kg of gold (Agnico-Eagle Mines Ltd., 2011, p. 7–8).

Ghana.—Production of gold in 2010 was 82,000 kg, which was 3% higher than that of 2009. Gold Fields purchased 18.9% of the Damang and Tarkwa Mines from IAMGOLD to bring its ownership to 90% of both mines with the remaining 10% held by the Government of Ghana. The Tarkwa Mine produced 22,900 kg of gold, 10% more than production in 2009 owing to increased throughput. The Damang Mine produced 7,090 kg of gold, 13% more than 2009 production because of commissioning of the secondary crusher (Gold Fields Ltd., 2011, p. 106–109).

Production from Newmont's Ahafo Mine was 17,000 kg, up slightly compared with 2009 gold production owing to an increase in ore grade. In 2010, AngloGold's Iduapriem and Obuasi Mines produced 15,600 kg of gold, 12% less than 2009 production. The drop in production was caused by a work stoppage at Iduapriem from February 11 to April 20 to increase capacity to the tailings storage facilities and less ore mined at Obuasi (AngloGold Ashanti Ltd., 2011, p. 84–88; Newmont Mining Corp., 2011, p. 62).

Production of gold at Golden Star Resources Ltd.'s (Littleton, CO) Wassa Mine was 22% lower than 2009 production because of unscheduled mill maintenance. Golden Star's Bogoso Mine produced 5,320 kg of gold in 2009, 9% less than that in 2009 because of wet weather (Golden Star Resources Ltd., 2011, p. 3, 13).

Guinea.—Gold production in 2010 fell by 16% compared with that of 2009. AngloGold's Siguiri Mine produced 9,980 kg of gold in 2010, 14% less than 2009 production because of lower ore grade (AngloGold Ashanti Ltd., 2011, p. 89–88). In 2010, SEMAFO's Kiniero Mine produced 936 kg of gold, 6% less than 2009 production (SEMAFO Inc., 2011, p. 11).

Indonesia.—In 2010, gold production fell to 120,000 kg, an 8% decrease compared with 2009 gold production. Some of the leading gold producers were copper mines that produced byproduct gold. Freeport McMoRan's Grasberg Mine and Newmont-operated Batu Hijau Mine represented 51% (60,700 kg) and 19% (22,900 kg), respectively, of Indonesian gold production in 2010. Production at Grasberg was 34% lower than production in 2009 because of mining in the lower grade zone of the pit. Production from Grasberg was expected to decrease again in 2011 as mining continued in the lower grade zone of the pit. In 2010, Batu Hijau's production was 32% more than 2009 production owing to higher grade ore (Freeport-McMoRan Copper & Gold Inc., 2011, p. 43; Newmont Mining Corp., 2011, p. 61).

Production was up at Newcrest's Gosowong Mine, which produced 14,900 kg of gold, 29% more than in 2009 (Newcrest Mining Ltd., 2011).

Kazakhstan.—In 2010, gold production was 29,900 kg, 33% greater than 2009 production. The main reason for the increase was the start up of Kazzinc JCS's (Ust-Kamenogorsk) Vasilkovskoje Mine in the second quarter of 2010. The mine was expected to reach full production capacity of 12,000 kg/yr of gold by the second quarter of 2011 (Klapwijk and others, 2011, p. 44).

Polyus Gold Mining Co. (Moscow, Russia) owned 65% of KazakhGold Group Ltd.'s (London) four mines in Kazakhstan. In 2010, the mines produced 6,890 kg of gold, which was 22% greater than 2009 because of continued modernization of the production facilities and the startup of the Akzhal Mine (Polyus Gold Mining Co., 2011, p. 4, 11, 19).

Kyrgyzstan.—Gold production for 2010 was 18,300 kg, an increase of 8% compared with that in 2009. Despite a 10-day shutdown, Centerra Gold Inc.'s (Toronto) Kumtor Mine produced 17,700 kg of gold in 2010, an 8% increase compared with 2009 production because of higher mill grades and increased recovery rates (Centerra Gold Inc., 2011, p. 15).

Mali.—AngloGold had interests in three gold mines in Mali—Morila (AngloGold and Randgold, 40% each, and the Government of Mali, 20%), Sadiola (AngloGold and IAMGOLD, 41% each; and the Government of Mali, 18%), and Yatela (AngloGold and IAMGOLD, 40% each, and the Government of Mali, 20%). In 2010, these mines produced 21,000 kg of gold, 26% less than gold production in 2009 (AngloGold Ashanti Ltd., 2011, p. 92–97).

The Morila Mine was operated by Randgold and produced 7,400 kg of gold in 2010. The 30% decrease in production compared with that of 2009 was because mining the open pit was completed in 2009, and the company was treating low-grade stockpiles. In 2011, production was projected to be about 4,000 kg of gold because only treatment of the low-grade stockpiles was scheduled to continue until 2013 (AngloGold Ashanti Ltd., 2011, p. 92–93).

The Sadiola operation consisted of five open pits that are approximately 77 km south of Kayes. In 2010, the operation produced 8,930 kg of gold, which was 19% less than production in 2009. The decrease was caused by lower ore grades owing to the depletion of the Sadiola main pit reserves. In 2011, production was projected to increase because of the addition of a gravity separation circuit (AngloGold Ashanti Ltd., 2011, p. 94–95).

In 2010, the Yatela Mine, 25 km north of Kayes, produced 4,670 kg of gold, a 32% decrease compared with 2009 production. The mine was originally scheduled to close in 2010, although the life has been extended. Production dropped in 2010 because of a decrease in ore grade processed (AngloGold Ashanti Ltd., 2011, p. 97–98).

Randgold owned 80% of the Loulo Gold Mine; the other 20% was owned by the Government of Mali. In 2010, the mine produced 9,850 kg of gold, which was 11% less than 2009 production because of lower throughput, which was a result of power outages and technical problems at the processing plant during the first 6 months of the year. The mine consists of three open pits, Gara, Loulo 3, and Yalea and two underground operations, Gara and Yalea (Randgold Resources Ltd., 2011, p. 16–18).

Mexico.—In 2010, Mexican gold production reached an alltime high of 72,600 kg, a 41% increase from 2009 production; production from newly opened mines was the principal factor in increased production. Goldcorp operated three mines in Mexico—El Sauzal, Los Filos, and Penasquito. On August 6, the company sold the San Dimas Mine to Primero Mining Corp. (Toronto). The Penasquito Mine started commercial production on September 1 and produced 5,230 kg of gold in 2010. In 2010, El Sauzal produced 4,730 kg gold, a 25% decrease compared with gold production in 2009 owing to the age of the mine and lower ore grades. The Los Filos Mine produced 9,520 kg of gold in 2010, 28% more than production in 2009 because of higher tonnage mined and the higher ore grade (Goldcorp Inc., 2011, p. 30–31, 51–52).

Fresnillo plc (London) operated three gold mines and one silver mine with byproduct gold production. In 2010, Fresnillo's gold production was 11,500 kg, 25% more than 2009 gold production. Fresnillo began production from the Soledad-Dipolos Mine in the first quarter of 2010. Combined with new production, Fresnillo also had increased production from the Cienega and Herradura Mines (Fresnillo plc, 2011, p. 34, 48–49).

Other mines that had increased production in 2010 were New Gold's Cerro San Pedro Mine which produced 3,690 kg of gold, 24% more than that in 2009 because higher ore grades and recovery rates more than offset the drop in tonnage mined (New Gold Inc., 2011a, p. 10–12). In 2010, Agnico-Eagle had its first full year of production from its open pit Pinos Altos Mine in Chihuahua State, producing 4,100 kg of gold (Agnico-Eagle Mines Ltd., 2011, p. 9–10). In 2009, Coeur d'Alene began gold production from its Palmarejo Mine, and in 2010, the mine produced 184,000 kg of silver and 3,190 kg of gold (Coeur d'Alene Mines Corp., 2011, p. 2).

On July 1, Gold Resources Corp. (Colorado Springs, CO), began commercial production from its El Aguila project and produced 326 kg of gold during the year. The company expected production to reach 2,000 kg by 2011 (Gold Resources Corp., 2011, p. 4). NWM Mining Corp. (Toronto) began dore production in December at its Lluvia-Jojoba Project in northern Sonora (NWM Mining Corp., 2010). SilverCrest Mines Inc. (Vancouver) began production from its Santa Elena Mine in September 2010 and produced 1,710 kg of silver and 67 kg of gold by yearend (SilverCrest Mines Inc., 2011).

Production at some mines decreased in 2010. Alamos Gold Inc.'s (Toronto) Mulatos Mine produced 4,850 kg of gold, a decrease of 14% because of adverse weather conditions that hampered mine operations (Alamos Gold Inc., 2011, p. 3–4). In 2010, Minefinders Corp. (Vancouver) produced 1,750 kg of gold from the Dolores Mine, 38% less than 2009 production (Minefinders Corp., 2011). The San Dimas Mine, acquired by Primero in 2010, produced 2,660 kg of gold and 141,000 kg of silver, 32% and 12% lower, respectively, than gold and silver production in 2009. However, production in 2011 was projected to be 15% more than 2010 production (Primero Mining Corp., 2011, p. 1, 9). Gammon Gold Inc. (Toronto) operated two mines, El Cuba and Ocampo. In 2010, the Ocampo Mine produced 3,130 kg of gold, 5% less than 2009 production. The El Cuba Mine produced 347 kg of gold in 2010, a 59% drop in production as compared with 2009 because of labor problems in 2010 (Gammon Gold Inc., 2011).

Mongolia.—Gold production in 2010 was 6,040 kg, 38% less than 2009 production partially owing to decreases at Centerra Gold's Boroo gold mine. Gold production from the mine was 3,460 kg in 2009, which was 26% lower owing to lower mill grades and a lower contribution from the heap-leaching operation, which was idle, awaiting a final operating permit. Mining activities ceased at the end of November, but the mill was expected to continue to operate for at least 2 years by processing stockpiled ores (Centerra Gold Inc., 2011, p. 19).

Namibia.—AngloGold's Navachab Mine produced 2,670 kg of gold in 2010, which was 32% higher than gold production in 2009. The increase was a result of greater volume mined from the bottom of the pit and the treatment of high-grade concentrates from the dense media separation plant, which was commissioned during 2010 (AngloGold Ashanti Ltd., 2011, p. 99–100).

New Zealand.—In 2010, gold production was 13,000 kg, a 3% decrease compared with production in 2009. Newmont's Waihi Mine produced 3,360 kg, 4% less than 2009 production because of a lower mill grade (Newmont Mining Corp., 2011, p. 61–62). In 2010, OceanaGold Corp. (Melbourne) produced 5,680 kg of gold from the Macraes Goldfield Mine, which was 17% less than 2009 production owing to lower grades from the open pit and the Frasers underground operations. OceanaGold's other operation, the Reefton Goldfield Mine, produced 2,670 kg of gold in 2010, which was slightly less than production in 2009 (OceanaGold Corp., 2011, p. 13).

Panama.—With production for the recently opened Petaquilla Minerals Ltd.'s (Vancouver) Molejon gold mine in November 2009, gold production in Panama jumped from 800 kg in 2009 to 1,300 kg in 2010. The company was planned to develop a heap-leaching operation in 2011 and expected to produce 1,560 kg of gold in 2012 (Redwood, 2011).

Papua New Guinea.—Production from Papua New Guinea mines remained the same as that in 2009. Barrick owned 95% of the Porgera Mine, and the Papua New Guinea Government held the remaining 5%. Barrick's share of production was 16,100 kg of gold in 2010, which was 6% lower than 2009 production because of low rainfall and water shortages, which led to lower mill throughput, and pit wall stability issues (Barrick Gold Corp., 2011a, p. 66; b).

In 2010, Newcrest produced 25,100 kg of gold, 5% more than that of 2009 from its Lihir Island operations. Newcrest also owed 50% of the Hidden Valley Mine, which started production in late 2009, and produced 5,260 kg of gold in 2010 (Newcrest Mining Ltd., 2011). Production at Ok Tedi Mining Ltd.'s (Tabubil) Ok Tedi Mine was 15,100 kg in 2010, 6% lower than 2009 production (Ok Tedi Mining Ltd., 2011).

Philippines.—Gold production from mines in the Philippines increased by 10%, to 40,800 kg of gold in 2010. Much of the increase was attributed to the ramp up of CGA Mining Ltd.'s (Perth) Masbate Mine, which started production in 2009. In 2010, the mine produced 5,680 kg of gold, up from 2009 gold production of 2,060 kg (CGA Mining Ltd., 2011). Production also increased at Medusa Mining Ltd.'s (Como, Western Australia, Australia) Co-O Mine, which produced 3,160 kg of gold in 2010, up 51% compared with 2009 production (Medusa Mining Ltd., 2011, p. 4).

Peru.—In 2010, gold production decreased by 10% to 164,000 kg compared with production in 2009. Newmont and Compañía de Minas Buenaventura S.A.A. (Lima) jointly owned the Yanacocha Mine in the Cajamarca District, which produced 45,500 kg of gold in 2010, 29% less than in 2009. The production decline was attributed to mine sequencing resulting in increased waste mining and lower grade ore (Newmont Mining Corp., 2011, p. 60).

Buenaventura owned or partly owned 11 other mines that produced gold in 2010. In 2010, excluding production from the Yanacocha Mine, Buenaventura produced 13,500 kg, slightly more than production in 2009 (Compañía de Minas Buenaventura S.A.A., 2011, p. 3).

Barrick's Lagunas Norte Mine produced 25,100 kg of gold in 2010, 20% less than production in 2009, because of the planned mining of lower grade ore in the second half of 2010. Barrick's other operation in Peru, Pierina Mine, neared the end of its economic mine life, and produced 5,940 kg of gold, 30% less than production in 2009 (Barrick Gold Corp., 2011a, p. 65; b).

In 2010, Gold Fields produced 4,730 kg of gold from the Cerro Corona copper and gold mine, 22% more than gold production in 2009. The increase was a result of processing higher grades, increased throughput, and enhanced recoveries (Gold Fields Ltd., 2011, p. 102–104).

Russia.—In 2010, Russian gold production was 192,000 kg, slightly less than 2009 production. The leading gold producer in Russia was Polyus Gold Mining Co. (Moscow) with 43,100 kg of production from five mines and several alluvial deposits, a 10% increase compared with 2009 production. Some of the increase was attributed to startup of the Blagodatnoye Mine in the Krasnoyarsk Region and startup of the largest capacity gold mill in Russia (Polyus Gold Mining Co., 2011, p. 4–9).

In 2010, the Kupol Mine (75% owned by Kinross) produced 23,000 kg of gold, 20% lower than production in 2009. Production was lower because of a 21% drop in ore grade resulting from planned mining sequencing and the processing of lower grade ore stockpiles (Kinross Gold Corp, 2011, p. 52–53).

In 2010, Petropavlovsk plc (London) produced 15,800 kg of gold, an increase of 4% compared with production in 2009. Petropavlovsk produced gold from three open pit mines (Malomir, Pioneer, and Pokrovskiy), alluvial operations, and joint ventures. Much of the increase was attributed to the startup of the Malomir Mine in August (Petropavlovsk plc, 2011, p. 3–7, 42).

In 2010, production from JSC Polymetal's (St. Petersburg) 14 gold-producing mines increased to 13,800 kg, a 30% increase from production in 2009. The increase was a result of an increase in the amount of ore processed in 2010 (JSC Polymetal, 2011).

Highland Gold Mining Ltd. (St. Helier, United Kingdom) (HGM) produced 6,220 kg of gold in 2010. This was 18% more than production in 2009 because the Belaya Gora Mine opened, and production from the Novoshirokinskoye and Mnogovershinnoye Mines increased (Highland Gold Mining Ltd., 2011, p. 4, 12–14).

South Africa.—In 2010, South Africa's gold production of 189,000 kg was a 5% decrease from that in 2009 owing to decreased ore grades and closure of under-producing shafts, which eventually was expected to decrease mining costs and increase mine production. Increased labor costs, higher costs associated with deep-level shafts, new royalties on mining revenue, power supply issues, and temporary closure of shafts owing to mine accidents continued to affect the industry and caused mine production to decline during the past 8 years to the lowest level since 1906 (CPM Group, 2011, p. 77–83).

In 2010, three companies operated mines that accounted for almost 80% of South African gold production. They were, in descending order of production, Gold Fields, AngloGold, and Harmony Gold Mining Co., Ltd. (Randfontein).

In 2010, Gold Fields's South African operations produced 58,000 kg of gold, 11% less than 2009 production from the Beatrix and South Deep Mines and the Kloof-Driefontein Complex (KDC). Only the South Deep Mine increased production in 2010 because of an increase in the amount of ore processed as the mine continued to ramp up to full production. In 2010, gold production at Beatrix was 6% lower and production from KDC was17% lower as compared with 2009 production. Safety-related work stoppages and the replacement of a water pump column were responsible for the decrease in production (Gold Fields Ltd., 2011, p. 96–100).

AngloGold had six deep-level mines and one surface operation in the West Wits and Vaal River regions that, combined, produced 53,500 kg of gold in 2010, 3% more than that in 2009. In 2010, the West Wits operations included the Mponeng, Savuka, and Tau Tona Mines and produced 25,300 kg of gold, 6% more than production in 2009. The Vaal River operations included the Great Noligwa, Kopanang, and Moab Khotsong Mines. Production for the Vaal River operations was 28,200 kg, slightly more than 2009 production. The production increase was attributed to the ramping up of the Moab Khotsong Mine, which produced 9,080 kg or 18% more in 2010 compared with that in 2009 and to an increase in ore grade at Tau Tona. This increase was partially offset by production declines at Great Noligwa, Kopanang, and Savuka following safety-related work stoppages and lower ore grades. Anglo Gold sold the Tau Lekoa Mine to Simmer and Jack Mines Ltd. (Johannesburg) on August 1 (AngloGold Ashanti Ltd., 2011, p. 58–81).

Harmony operated 11 underground mines, 2 surface operations, and several other gold-producing operations in South Africa. In 2010, production from Harmony's operations was 39,000 kg of gold, 12% less than that in 2009. Underground operations produced 15% less gold in 2010 than that of 2009. Much of the decrease came from Virginia (3,560 kg less) and Evander (2,780 kg less). In 2010, Harmony closed shafts at the Virginia and Evander operations, which led to a 51% and 55% decrease, respectively, as compared with 2009 production. In 2010, production from surface operations increased by 23% from 2009 production, which resulted from processing a greater quantity of waste rock dumps (Harmony Gold Mining Co., Ltd., 2011, p. 6–11).

Simmer and Jack Mines operated the Buffelsfontein and the Transvall gold mines. In 2010, these mines produced 3,730 kg of gold, 7% less than in 2009 owing to the closure of underground mining at Transvall and closure of two shaft complexes at Buffelsfontein as well as safety-related work stoppages (Simmer and Jack Mines Ltd., 2011, p. 16–21).

In 2010, Gold One International Ltd. (Sydney) produced 2,070 kg of gold from its Modder East Mine in its first full year of production; the mine began production in the second quarter of 2009 (Gold One International Ltd., 2011, p. 7). First Uranium Corp. (Toronto) produced gold from its Ezulwini underground operations and from its Mines Waste Solutions (MWS). In 2010, Ezulwini sold 1,860 kg of gold and MWS sold 2,580 kg of gold, more than 2009 production (First Uranium Corp., 2011).

Sudan.—Gold production in 2010 was estimated to be 4,000 kg, more than double 2009 production. The country's only large-scale gold mine was the Hassai Mine, which was operated and 40%-owned by La Mancha, produced 2,130 kg of gold, 11% more than 2009 gold production (La Mancha Resources Inc., 2011). The remaining production from small-scale and artisanal mines increased substantially because of the sharp increase in gold price in 2010 (Klapwijk and others, 2011, p. 42).

Suriname.—IAMGOLD's Rosbel Mine was the leading gold-producing mine in the country with 12,300 kg of gold produced, slightly more than in 2009. The increase was attributed to higher mill throughput (IAMGOLD Corp., 2011, p. 16).

Tajikistan.—In 2010, gold production increased by 51% to 2,050 kg, compared with production in 2009. The country had 3 gold producers and 31 gold deposits with estimated reserves of 675 t of gold. The Zerfshan joint venture, 75% owned by Zijin Mining, produced 1,220 kg of gold in 2010 (Interfax Russia & CIS Metals and Mining Weekly, 2011).

Tanzania.—In 2010, gold production increased by 7% to 42,000 kg, compared with 2009 production. In March, Barrick created African Barrick Gold plc (London) to hold Barrick's African gold mines, gold projects, and gold exploration properties. Barrick's share of gold production from Tanzania operations was 17,500 kg, a 21% decrease from that in 2009. In 2010, Barrick's share of Buzwagi Mine production was 4,700 kg of gold, 20% less than production in 2009. Barrick's gold production shares of the Balyanhulu and North Mara Mines, were 16% and 19% less, respectively, in 2010 compared with 2009 production. Production from the Tulawaka gold mine [70% owned by Barrick and 30% owned by MDN Inc. (Montreal)] was 1,060 kg of gold in 2010, a decrease of 48% compared with production in 2009 because of lower ore grade (Barrick Gold Corp., 2011a, p. 66–67; b).

AngloGold's Geita Mine produced 11,100 kg of gold in 2010, 31% more than production in 2009. Improvements in ore grades were the main reason for the increase; however, some of this increase was offset by a planned mill shutdown in the third quarter (AngloGold Ashanti Ltd., 2011, p. 101–102).

Turkey.—With 700 t of gold reserves and five active gold mines in 2010, gold production was 17,000 kg, an increase of 17% compared with that of 2009. The Eldorado Gold Kisladag Mine, the leading gold mine in Turkey, produced 8,540 kg of gold, 14% more than in 2009. The proven and probable reserves for the mine were estimated to be 318,000 kg of contained gold (Eldorado Gold Corp., 2011, p. 6, 8; Sener, 2011).

Outlook

Worldwide and domestic gold production was expected to increase in 2011 because of new mines starting production and older mines expanding production. Gold consumption was expected to continue to increase because jewelry consumption in China and India were expected to continue to increase. The increases in China and India are likely to outpace the declines in jewelry consumption in rest of the world and from decreases in consumption in other end uses because of higher gold prices. Investment in gold in various forms was expected to continue to increase as investors purchase gold as a safe haven, a hedge against economic failures, a portfolio diversifier, and as a store of wealth.

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TABLE 1

SALIENT GOLD STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Production:						
Mine:						
Quantity	kilograms	252,000	238,000	233,000	223,000	231,000
Value	thousands	$4,910,000	$5,350,000	$6,550,000	$7,000,000	$9,130,000
Gold recovered by cyanidation:						
Extracted in vats, tanks, closed containers[2]	kilograms	W	W	W	W	W
Leached in open heaps or dumps[3]	do.	217,000	207,000	194,000	188,000	192,000
Refinery:						
Concentrates and dore	do.	181,000	176,000	168,000	170,000	175,000
Recycled materials (new and old scrap)	do.	89,100	135,000	181,000	189,000	198,000
Exports, refined	do.	228,000	392,000	459,000	281,000	295,000
Imports for consumption, refined	do.	136,000	113,000	118,000	127,000	199,000
Net deliveries from foreign stocks in Federal Reserve Bank of New York	do.	--	189,000	220,000	--	--
Stocks, December 31:						
Industry[4]	do.	2,000	1,140	W	9,200	6,810
Gold exchange traded funds holdings, United States only	do.	498,000	683,000	847,000	1,220,000	1,450,000
COMEX	do.	234,000	229,000	265,000	305,000	361,000
U.S. Department of the Treasury	metric tons	8,140	8,140	8,140	8,140	8,140
U.S. Gold Futures Trading[5]	do.	49,500	77,900	11,900	110,000	139,000
Consumption:						
American Buffalo Bullion gold coin[6]	kilograms	10,500	4,250	5,890	6,220	6,500
American Eagle gold coin[6]	do.	9,770	12,800	35,600	44,300	38,000
In industry and the arts	do.	185,000	180,000	176,000	150,000	180,000
Price, average[7]	dollars per troy ounce	605.83	698.95	873.50	974.68	1,227.51
Employment, mine and mill only[8]		8,350	9,130	9,560	9,650	10,200
World:						
Production, mine	kilograms	2,370,000	2,350,000 [r]	2,280,000 [r]	2,460,000 [r]	2,560,000 [e]
Official bullion reserves[9]	metric tons	30,400	29,900	28,700	30,700	31,100

[e]Estimated. [r]Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits, except prices.

[2] May include small quantities recovered by gravity methods.

[3] May include tailings, waste-ore dumps, and previously mined ore at some inactive mines.

[4] Unfabricated refined gold held by refiners, fabricators, dealers, and the U.S. Department of Defense.

[5] COMEX only.

[6] Data from U.S. Mint.

[7] Engelhard quotation.

[8] Data from the Mine Safety and Health Administration.

[9] Held by central banks, governments, and international monetary organizations. Data from the International Monetary Fund.

TABLE 2

MINE PRODUCTION OF GOLD IN THE UNITED STATES, BY STATE[1]

(Kilograms)

State	2009	2010
Alaska	W	28,100
Nevada	161,000	166,000
Other States[2]	62,500	36,900
Total	223,000	231,000

W Withheld to avoid disclosing company proprietary data; included in "Other States."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Arizona, California, Colorado, Idaho, Montana (2009), New Mexico, South Dakota, Utah, and Washington.

TABLE 3

LEADING GOLD-PRODUCING MINES IN THE UNITED STATES IN 2010, IN ORDER OF OUTPUT[1]

Rank	Mine	County and State	Majority owner	Quantity (kilograms)
1	Goldstrike[2]	Elko and Eureka, NV	Barrick Gold Corp.	36,300
2	Cortez[3]	Lander, NV	do.	35,500
3	Eastern Nevada Operations[4]	Eureka, NV	Newmont Mining Corp.	29,100
4	Bingham Canyon[5]	Salt Lake, UT	Kennecott Utah Copper Corp.[6]	14,500
5	Twin Creeks	Humboldt, NV	Newmont Mining Corp.	14,100
6	Pogo	Southeast Fairbanks, AK	Sumitomo Metal Mining Co.	11,900
7	Smoky Valley Common Operation	Nye, NV	Kinross Gold Corp.	11,200
8	Fort Knox	Fairbanks North Star, AK	do.	10,900
9	Cresson	Teller, CO	AngloGold Ashanti Ltd.	7,250
10	Phoenix	Lander, NV	Newmont Mining Corp.	6,660
11	Kettle River-Buckhorn	Okanogan, WA	Kinross Gold Corp.	6,180
12	Mesquite	Imperial, CA	New Gold Inc.	5,260
13	Turquoise Ridge	Humboldt, NV	Barrick Gold Corp.	5,140
14	Marigold	do.	Goldcorp Inc.	4,250
15	Midas	Elko, NV	Newmont Mining Corp.	3,960
16	Hollister	do.	Great Basin Gold Ltd.	3,270
17	Hycroft	Humboldt and Pershing, NV	Allied Nevada Gold Corp.	3,190
18	Ruby Hill	Eureka, NV	Barrick Gold Corp.	2,530
19	Storm	Elko, NV	do.	2,320
20	Wharf	Lawrence, SD	Wharf Resources (USA) Inc.[7]	2,280
21	Robinson	White Pine, NV	Quadra Mining Ltd.	2,270
22	Greens Creek	Juneau, AK	Hecla Mining Co.	2,140
23	Jerritt Canyon	Elko, NV	Yukon-Nevada Gold Corp.	2,030
24	Bald Mountain	White Pine, NV	Barrick Gold Corp.	1,800
25	Florida Canyon	Pershing, NV	Jipangu Inc.	1,710
26	Kensington	Juneau, AK	Coeur d'Alene Mines Corp.	1,340
27	Briggs	Inyo, CA	Atna Resources Ltd.	784
28	Denton-Rawhide	Mineral, NV	Rawhide Acquisition Holdings[8]	627
29	Rochester	Pershing, NV	Coeur d'Alene Mines Corp.	300
(9)	Mission Complex	Pima, AZ	ASARCO LLC[10]	NA

do. Ditto. NA Not available.

[1] Data are rounded to no more than three significant digits; the mines on this list accounted for more than 99% of U.S. mine production in 2010.

[2] Formerly listed as Betze-Post Mine.

[3] Includes Cortez Hills and Cortez Pipeline Mines.

[4] Includes Carlin East, Deep Post, Gold Quarry, and Pete Mines.

[5] Quantity refers to total quantity of gold produced in concentrates.

[6] Wholly owned subsidiary of Rio Tinto plc.

[7] Wholly owned subsidiary of Goldcorp Inc.

[8] Rawhide Acquisition Holdings purchased 100% interest from Rio Tinto plc. on June 25, 2010.

[9] Mine is ranked in the top 30 in the United States in 2010; however, public data were not available. The rank order is not shown to avoid disclosing company proprietary data.

[10] Wholly owned subsidiary of Grupo Mexico, S.A.B. de C.V.

Sources: Company annual reports, company 10–K reports submitted to the U.S. Securities and Exchange Commission, company news releases, and Nevada Bureau of Mines and Geology.

TABLE 4
U.S. EXPORTS OF GOLD, BY COUNTRY[1, 2]

Year and country	Ores and concentrates[3]		Dore and precipitates		Refined bullion[4]		Total	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
2009	2,160	$48,600	97,400	$3,000,000	281,000	$8,760,000	381,000	$11,800,000
2010:								
Australia	129	5,310	--	--	14,100	573,000	14,200	578,000
Austria	--	--	378	12,700	187	6,370	565	19,100
Belgium	--	--	--	--	14	497	14	497
Brazil	--	--	--	--	50	2,240	50	2,240
Canada	--	--	131	4,630	8,620	338,000	8,750	343,000
China	536	19,900	--	--	23	901	558	20,800
Costa Rica	798	13,400	--	--	--	--	798	13,400
Czech Republic	--	--	--	--	6	250	6	250
Dominican Republic	19	138	--	--	28	882	47	1,020
France	--	--	--	--	186	7,130	186	7,130
Germany	963	35,200	4	79	427	12,700	1,390	47,900
Guatemala	--	--	--	--	36	1,050	36	1,050
Hong Kong	161	6,320	--	--	18,200	747,000	18,400	753,000
India	--	--	--	--	30,900	1,180,000	30,900	1,180,000
Indonesia	--	--	--	--	243	9,150	243	9,150
Ireland	147	1,990	--	--	4	104	151	2,090
Japan	2	14	--	--	10	214	12	228
Korea, Republic of	220	9,070	--	--	10	398	231	9,470
Laos	--	--	--	--	14	415	14	415
Latvia	12	246	--	--	--	--	12	246
Lebanon	--	--	--	--	15	528	15	528
Malaysia	--	--	--	--	253	9,810	253	9,810
Mexico	452	10,400	12	160	1,800	61,800	2,270	72,300
Oman	--	--	--	--	256	10,100	256	10,100
Pakistan	--	--	4	130	53	2,080	57	2,210
Peru	--	--	9	326	45	1,740	54	2,070
Singapore	(5)	3	--	--	126	4,720	126	4,720
South Africa	--	--	--	--	9,510	374,000	9,510	374,000
Switzerland	5	116	83,600	3,130,000	29,300	1,130,000	113,000	4,270,000
Thailand	1	11	--	--	5,000	192,000	5,000	192,000
Turkey	--	--	--	--	1,050	39,800	1,050	39,800
Ukraine	--	--	--	--	861	30,700	861	30,700
United Arab Emirates	--	--	--	--	3,080	117,000	3,080	117,000
United Kingdom	13	237	126	2,130	170,000	6,580,000	170,000	6,580,000
Uruguay	--	--	79	2,460	--	--	79	2,460
Vietnam	--	--	--	--	39	836	39	836
Other	6	62	2	69	5	165	13	296
Total	3,460	102,000	84,400	3,160,000	295,000	11,400,000	383,000	14,700,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Ash and residues data were zero for listed years.

[3] Includes base-metal ores, concentrates, and matte destined for refining.

[4] Bullion also moves in both directions between U.S. markets and foreign stocks on deposit in the Federal Reserve Bank. Monetary gold is excluded.

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5

U.S. EXPORTS OF GOLD, BY COUNTRY[1]

	Waste and scrap		Metal powder		Gold compounds	
Year and country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
2009	728,000	$1,750,000	329	$8,460	2,680,000	$64,600
2010:						
Antigua and Barbuda	--	--	--	--	311	6
Aruba	--	--	--	--	1,020	18
Australia	24	3	1	21	992	18
Bahamas, The	--	--	--	--	236	4
Belgium	2,820	3,550	--	--	--	--
Belize	--	--	--	--	544	4
Bolivia	--	--	11	11	2,490	45
Canada	72,200	1,530,000	73	1,040	640,000	11,500
Cayman Islands	--	--	--	--	1,900	34
China	--	--	24	394	597,000	18,800
Costa Rica	--	--	5	95	6,710	121
Denmark	46	1,800	--	--	--	--
Dominican Republic	--	--	2	21	73,900	1,330
Ecuador	--	--	--	--	900	28
France	--	--	22	382	3,400	64
Germany	349,000	81,200	10	323	21,800	389
Hong Kong	860	5,010	20	363	33,100	334
India	3	37	53	1,750	9,030	163
Ireland	--	--	--	--	18,900	340
Israel	--	--	(2)	9	2,800	50
Italy	2	20	--	--	2,290	25
Jamaica	--	--	--	--	2,570	46
Japan	2,820	20,000	41	835	1,430	26
Korea, Republic of	1,110	228	3	44	10,400	187
Lebanon	--	--	--	--	4,400	79
Liechtenstein	15	276	--	--	--	--
Malaysia	--	--	--	--	203,000	3,860
Mexico	--	--	3	82	569,000	10,300
Netherlands	--	--	10	138	66,500	1,200
Netherlands Antilles	--	--	--	--	506	9
Norway	--	--	--	--	488	9
Romania	--	--	--	--	693	12
Saudi Arabia	--	--	--	--	785	14
Singapore	--	--	8	38	1,710,000	53,000
South Africa	--	--	1	13	645	12
Sri Lanka	--	--	28	395	--	--
Sweden	--	--	--	--	633	11
Switzerland	10,400	396,000	1,710	60,500	583	11
Taiwan	--	--	11	222	256,000	4,560
Thailand	1	45	--	--	5,700	102
Turkey	--	--	23	832	--	--
United Arab Emirates	1,210	27,400	36	618	--	--
United Kingdom	219,000	118,000	246	6,610	13,600	211
Vietnam	--	--	--	--	1,850	33
Other	29	19	--	3	368	7
Total	660,000	2,180,000	2,340	74,700	4,270,000	107,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF GOLD, BY COUNTRY[1]

	Ores and concentrates[2]		Dore and precipitates		Refined bullion[3]		Total	
Year and country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
2009	46,600	$33,100	146,000	$4,260,000	127,000	$3,580,000	320,000	$7,870,000
2010:								
Argentina	--	--	86	5,010	924	38,800	1,010	43,800
Australia	10	161	8	133	736	23,100	754	23,400
Bahamas, The	--	--	50	1,180	--	--	50	1,180
Bolivia	--	--	114	3,930	108	3,370	223	7,300
Brazil	--	--	121	4,890	3,830	149,000	3,950	154,000
Burkina Faso	--	--	2	82	63	1,470	65	1,550
Canada	83	971	662	25,300	102,000	4,200,000	103,000	4,230,000
Chile	--	--	1,520	64,100	3,940	151,000	5,460	215,000
China	--	--	--	--	11	432	11	432
Colombia	--	--	24,700	801,000	19,000	629,000	43,800	1,430,000
Costa Rica	--	--	588	11,100	19	377	608	11,500
Dominican Republic	--	--	373	7,680	45	903	418	8,580
Ecuador	--	--	161	5,130	108	2,680	268	7,810
El Salvador	--	--	--	--	35	516	35	516
France	--	--	--	--	834	17,400	834	17,400
Germany	--	--	7	152	632	20,100	639	20,200
Ghana	--	--	104	2,660	227	8,270	331	10,900
Guatemala	--	--	5,370	198,000	11	130	5,380	198,000
Guinea	--	--	--	--	25	275	25	275
Guyana	--	--	4,120	154,000	1,260	49,700	5,380	204,000
Honduras	--	--	363	11,700	5,100	70,800	5,460	82,500
Hong Kong	--	--	--	--	413	16,400	413	16,400
Israel	--	--	--	--	23	975	23	975
Jamaica	--	--	137	3,480	136	1,690	273	5,170
Mali	--	--	20	628	32	1,120	53	1,750
Mexico	257,000	56,900	91,000	2,640,000	49,300	1,320,000	397,000	4,010,000
Netherlands Antilles	--	--	845	30,600	95	3,810	940	34,400
Nicaragua	--	--	1,470	50,700	84	1,310	1,560	52,000
Panama	--	--	373	8,760	449	14,000	822	22,700
Peru	--	--	14,100	469,000	361	9,050	14,400	478,000
South Africa	--	--	3	102	1,990	73,900	1,990	74,000
Sweden	--	--	--	--	28	831	28	831
Switzerland	--	--	149	5,380	3,540	142,000	3,690	148,000
United Arab Emirates	--	--	--	--	6	224	6	224
United Kingdom	--	--	1,520	15,300	3,770	65,000	5,290	80,200
Other	--	--	6	203	28	821	33	1,030
Total	257,000	58,000	148,000	4,520,000	199,000	7,020,000	604,000	11,600,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes base metal ores, concentrates, and matte destined for refining.

[3] Bullion also moves in both directions between U.S. markets and foreign stocks on deposit in the Federal Reserve Bank. Monetary gold is excluded.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS FOR CONSUMPTION OF GOLD, BY COUNTRY[1]

	Waste and scrap		Metal powder		Gold compounds	
Year and country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
2009	43,400	$600,000	476	$8,760	64,300	$1,430
2010:						
Antigua and Barbuda	9	154	--	--	--	--
Aruba	97	1,450	1	20	--	--
Australia	--	--	14	111	--	--
Bahamas, The	526	4,860	--	--	--	--
Belize	30	479	--	--	--	--
Bolivia	88	2,260	--	--	--	--
Canada	8,900	134,000	16	38	--	--
Cayman Islands	11	199	--	--	--	--
China	11	191	--	--	--	--
Colombia	23	723	--	--	--	--
Congo (Kinshasa)	--	--	25	600	--	--
Costa Rica	2,360	26,800	--	--	--	--
Dominican Republic	10,500	204,000	17	181	--	--
Ecuador	26	621	--	--	--	--
El Salvador	4,730	83,000	--	--	--	--
Germany	13	74	16	243	9,180	267
Ghana	--	--	364	7,280	--	--
Guatemala	2,050	20,200	--	--	--	--
Honduras	4,260	75,800	--	--	--	--
Israel	1	32	9	218	--	--
Italy	208	2,040	3	59	--	--
Jamaica	702	9,380	--	--	--	--
Japan	2	41	1	13	24,200	844
Korea, Republic of	5	92	(2)	11	--	--
Malaysia	61	1,190	--	--	--	--
Mali	--	--	50	607	--	--
Mexico	6,500	71,600	41	436	--	--
Netherlands	8	67	--	--	9,510	317
Netherlands Antilles	452	9,970	--	--	--	--
Nicaragua	1,790	31,600	1	34	--	--
Panama	1,490	29,700	--	--	--	--
Sierra Leone	1	28	76	1,260	--	--
Singapore	34	307	3	23	--	--
St. Lucia	61	869	--	--	--	--
Switzerland	(2)	2	9	312	--	--
Taiwan	11	414	--	--	--	--
Trinidad and Tobago	19	333	--	--	--	--
United Kingdom	992	7,600	5	77	601	34
Venezuela	9	165	--	--	--	--
Other	89	1,280	1	30	2	14
Total	46,100	722,000	652	11,500	43,500	1,480

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8

GOLD: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

Country	2006	2007	2008	2009	2010[e]
Algeria	377	236	656	1,010	740
Argentina	44,131	42,021	42,046	46,588 [r]	60,000
Armenia	1,300 [e]	1,300 [e]	1,359	944	2,000 [3]
Australia	247,000	247,000 [e]	215,000	224,000 [r]	261,000
Azerbaijan	--	--	--	353	1,900 [3]
Belize[e]	5 [3]	5	5	5	--
Benin[e]	24	19	20	20	20
Bolivia	9,628	8,818	8,406 [r]	7,217 [r]	6,394 [p, 3]
Botswana[e]	2,800	2,800	3,300	2,000	2,400
Brazil[4]	43,082	49,613 [r]	54,666 [r]	56,062 [r]	58,000 [p]
Bulgaria	3,818	3,964	4,160	4,482 [r]	3,500
Burkina Faso	1,571	2,250	7,633	13,500	25,000
Burma[e]	100	100	100	100	100
Burundi[e]	750	750	750	750	750
Cameroon[e]	1,500	1,500	1,500	1,600	1,600
Canada	103,513	102,211	95,004	97,367	91,024 [3]
Central African Republic[e]	10	10	43 [r]	61 [r]	60
Chad[e]	150	150	100	100	100
Chile	42,100	41,527	39,162	40,834	38,417 [3]
China[e]	245,000	275,000	285,000	320,000	345,000
Colombia	15,683	15,482	34,321	47,837	53,605 [3]
Congo (Brazzaville)[e]	100	100	100	100	100
Congo (Kinshasa)[e]	10,300	5,100	3,300	3,500 [r]	3,500
Costa Rica	1,210	2,065	154 [r]	209 [r]	200
Côte d'Ivoire	1,324	1,243	2,836	6,647 [r]	5,800 [3]
Denmark[5]	1,129	1,861	1,665	1,117 [3]	1,200 [3]
Dominican Republic	--	--	47	375	500
Ecuador[6]	5,168	3,186	800	2,092	2,000 [3]
Egypt	--	--	--	60	2,586 [3]
Equatorial Guinea[e]	200	200	200	200	200
Eritrea[e]	30	30	30	30	30
Ethiopia[7]	4,028	4,368	3,159 [r]	4,005 [r]	12,000
Fiji	1,961 [r]	837 [r]	871 [r]	1,040 [r]	1,856 [3]
Finland[e]	5,000	5,000	5,000	7,000	7,000
France[e]	1,500	1,500	1,500	1,500	1,500
French Guiana[e]	2,000	2,000	2,000	2,000	2,000
Gabon[e, 8]	300	300	300	300	300
Georgia[e]	2,000	2,000	2,000	2,000	2,000
Ghana	69,817	72,209 [r]	72,980 [r]	79,883 [r]	82,000
Greece	--	--	400	500	500
Guatemala	5,036	7,497 [r]	7,837 [r]	8,897 [r]	9,000 [3]
Guinea	16,922	15,628	19,945	18,091 [r]	15,217 [3]
Guyana	5,668	7,412	8,131	9,326 [r]	9,593 [3]
Honduras	4,100	3,275	2,561	2,127	2,200 [3]
India[9]	2,400	3,000 [e]	2,700	2,800	2,700
Indonesia[10]	93,176	117,851	64,390	130,000	120,000
Iran[e]	200	252 [3]	400	400	400
Italy[e]	200 [3]	450	450	450	450

See footnotes at end of table.

TABLE 8—Continued
GOLD: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

Country	2006	2007	2008	2009	2010[e]
Japan	8,904	8,869	6,868	7,708[r]	7,500[3]
Kazakhstan	21,824[r]	22,564[r]	20,825[r]	22,525[r]	29,941[3]
Kenya	432	3,023	340	1,055[r]	1,200
Korea, North[e]	2,000	2,000	2,000	2,000	2,000
Korea, Republic of	277	162	175	274[r]	300
Kyrgyzstan	10,721	10,559	18,132	16,950	18,300
Laos	6,068[r]	5,137[r]	4,333[r]	5,033[r]	5,061
Liberia	9	311[e]	624	524[r]	800
Madagascar[e]	30	50	72[3]	70	70
Malaysia	3,497	2,913	2,489	2,794	2,900[3]
Mali	51,957	48,850	41,160	42,364[r]	37,000
Mauritania	322	2,251	6,254	8,000	10,000
Mexico	38,961	39,355	50,365	51,393	72,596[3]
Mongolia	22,561	17,473	15,184	9,803	6,037[3]
Morocco[e]	1,200	1,200	1,200	1,200	1,200
Mozambique	85	97	298	511	520[3]
Namibia	2,790	2,496	2,126	2,022	2,675[3]
New Zealand	10,618	10,638	13,402	13,442	13,000[3]
Nicaragua[e]	3,595[3]	3,300[r]	2,960[r]	2,590[r]	2,600
Niger	2,615	3,427	2,314	1,852[r]	1,700
Nigeria[e]	40	180	200	600[r]	600
Oman	186	124	46	28	--[3]
Panama	--	--	--	800	1,300
Papua New Guinea	58,349	57,549[r]	67,463[r]	67,800[r]	67,800
Peru[11]	202,826	170,236	179,870[r]	182,403[r]	164,060[3]
Philippines	36,141	38,792	35,726	37,047	40,847[3]
Poland	500[r]	450[r]	430[r]	440[r]	425
Romania[e]	400	400	400	400	400
Russia[12]	159,340	156,975	172,031	192,832[r]	192,034[3]
Rwanda[e]	15	17[3]	20	20	20
Saudi Arabia	5,200[e]	4,440	4,527	5,500	4,500[3]
Senegal[e]	600	600	600	4,535[r, 3]	4,880
Serbia[e]	450	500	500	450[r]	722
Sierra Leone	71	212[e]	196	157[r]	150
Slovakia	84	198[r]	92[r]	346[r]	340
Solomon Islands[e]	10	--	--	--	--
South Africa	272,128	252,598	212,744	197,628[r]	188,701[3]
Spain	3,421	3,500[e]	3,400	3,450	3,500
Sudan	3,158	2,703	2,276	1,922	4,000
Suriname	9,362	9,360	9,798	12,193	12,286[3]
Sweden[e]	5,100	5,000	5,000	5,000	5,000
Tajikistan	1,920	2,000	1,672	1,361	2,049[3]
Tanzania	47,000	40,193	36,434	39,112[r]	42,000
Thailand	4,300	3,401	2,721	5,400[r]	5,000
Turkey	8,040	9,920	11,016[r]	14,469[r]	17,000
Uganda[e]	1,600	1,600	1,500	1,600	1,600
United Kingdom	--	--	164	185	171
United States	252,000	238,000	233,000	223,000	231,000[3]

See footnotes at end of table.

TABLE 8—Continued

GOLD: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

Country	2006	2007	2008	2009	2010[e]
Uruguay	3,000	2,820	2,182	2,180	2,000
Uzbekistan[e]	85,000	85,000	85,000	90,000	90,000
Venezuela	11,600 [e]	10,100	10,100 [e]	11,880 [r]	12,000
Vietnam[e]	2,500	3,000	3,000	3,000	3,500
Zambia	956	1,270	1,930	3,100 [r]	3,400
Zimbabwe	11,354	7,018 [r]	3,579 [r]	4,966 [r]	9,000
Total	2,370,000	2,350,000 [r]	2,280,000 [r]	2,460,000 [r]	2,560,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 19, 2011.

[3] Reported figure.

[4] Officially reported figures are as follows, in kilograms: Major companies: 2006—37,907; 2007—44,790; 2008—48,373; 2009—48,000; and 2010—50,000 (estimated). Garimpieros: 2006—5,175; 2007—5,210; 2008—5,627; 2009—6,000 (revised); and 2010—6,100 (estimated).

[5] All production from Greenland.

[6] Includes undocumented artisanal production.

[7] Year ending July 7 of that stated.

[8] Undocumented artisanal production.

[9] Refinery output.

[10] Excludes production from so-called people's mines, which may be as much as 20,000 kilograms per year, but includes gold recovered as byproduct of copper mining.

[11] Includes documented production from placer artisanal production.

[12] Mine output including gold recovered as a byproduct, but excludes secondary gold production, which for Russia, in kilograms, was 2006—4,981; 2007—5,867; 2008—8,140; 2009—14,534 (revised); and 2010—16,815.

GRAPHITE

By Donald W. Olson

Domestic survey data and tables were prepared by Mary E. Ewell, industry data analyst, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, there was no reported domestic production of natural graphite, but U.S. production of synthetic graphite was estimated to be 134,000 metric tons (t) valued at about $1.07 billion. U.S. imports and exports of natural graphite were estimated to be 65,400 t and 5,600 t, respectively. U.S. imports and exports of synthetic graphite were estimated to be 41,300 t and 40,000 t, respectively. U.S. apparent consumption of natural and synthetic graphite was estimated to be 59,800 t and 135,000 t, respectively.

This report includes information on U.S. trade and use of natural graphite and U.S. production, trade, and use of synthetic graphite. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using the unrounded data.

Graphite is one of four forms of crystalline carbon; the others are carbon nanotubes, diamonds, and fullerenes. In graphite, the carbon atoms are densely arranged in parallel-stacked, planar honeycomb-lattice sheets. When the graphite structure is only a one-atom-thick planar sheet, it is called graphene. Graphite is gray to black in color, opaque, and usually has a metallic luster; sometimes it exhibits a dull earthy luster. Graphite occurs naturally in metamorphic rocks. It is a soft mineral with a Mohs hardness of 1 to 2, and it exhibits perfect basal (one-plane) cleavage. Graphite is flexible but not elastic, has a melting point of 3,927 °C, and is highly refractory. It has a low specific gravity. Graphite is the most electrically and thermally conductive of the nonmetals and is chemically inert. All these properties combined make graphite desirable for many industrial applications, and both natural and synthetic graphite have industrial uses.

There are three types of natural graphite—amorphous, flake or crystalline flake, and vein or lump. Amorphous graphite is the lowest quality and most abundant. Amorphous refers to its very small crystal size and not to a lack of crystal structure. Amorphous is used for lower value graphite products and is the lowest priced graphite. Large amorphous graphite deposits are found in China, Europe, Mexico, and the United States. Flake or crystalline form of graphite consists of many graphene sheets stacked together. Flake or crystalline flake graphite is less common and higher quality than amorphous. Flake graphite occurs as separate flakes that crystallized in metamorphic rock. Flake graphite can be four times the price of amorphous. Good quality flakes can be processed into expandable graphite for many uses, such as flame retardants. The foremost deposits are found in Austria, Brazil, Canada, China, Germany, and Madagascar. Vein or lump graphite is the rarest, most valuable, and highest quality type of natural graphite. It occurs in veins along intrusive contacts in solid lumps, and it is only commercially mined in Sri Lanka (Moores, 2007).

Natural graphite is mined from open pit and underground mine operations. Production from open pit operations is less expensive and is preferred where the overburden can be removed economically. Mines in Madagascar are mostly of this type. In Mexico, the Republic of Korea, and Sri Lanka, where the deposits are deep, underground mining techniques are required.

Beneficiation processes for graphite may vary from a complex four-stage flotation at European and United States mills to simple hand sorting and screening of high-grade ore at Sri Lankan operations. Certain soft graphite ores, such as those found in Madagascar, need no primary crushing and grinding. Typically, such ores contain the highest proportion of coarse flakes. Ore is sluiced to the field washing plant, where it undergoes desliming to remove the clay fraction and is subjected to a rough flotation to produce a concentrate with 60% to 70% carbon. This concentrate is transported to the refining mill for further grinding and flotation to reach 85% carbon. It is then screened to produce a variety of products marketed as flake graphite that contain 75% to 90% carbon.

Production

The U.S. Geological Survey (USGS) obtained the production data in this report through a voluntary survey of U.S. synthetic graphite producers. The survey of U.S. synthetic graphite producers collected data from 10 of 16 canvassed producers. Data were estimated for the producers that did not respond to the survey based on responses received in previous years and on industry trends.

No natural graphite was reported mined in the United States in 2010, but 134,000 t of synthetic graphite with an estimated value of $1.07 billion was produced and shipped (table 3).

Consumption

The USGS obtained the consumption data in this report through a survey of natural graphite companies in the United States. The survey of natural graphite companies collected data from 70 of 91 canvassed companies and plants. Data were estimated for the companies that did not respond to the survey. This survey represented most of the graphite industry in the United States. Graphite uses have changed dramatically in the past 20 years. U.S. reported consumption of natural graphite increased by 28% to 51,200 t in 2010 from 40,000 t in 2009 (table 2), owing to increases of 21%, 37%, and 77% from the previous year in the amounts of natural graphite used in batteries, refractories, and the "Other" end-use category, respectively. The "Other" end-use category includes antiknock gasoline additives and other chemical compounds, drilling mud, electrical/electronic devices, industrial diamonds, magnetic tape, mechanical products, paints and polishes, soldering/welding, and other end uses. The natural graphite consumption data in table 2 include mixtures of natural and synthetic graphite in the amorphous graphite category, and this reported consumption data may include company stocks from previous years. Consequently, the table 2 consumption numbers are different from the computed apparent consumption numbers given in table 1. Consumption of crystalline grade increased in 2010 by 51% to 25,600 t from 16,900 t in 2009. Consumption of amorphous grade increased by 11% to 25,700 t in 2010 from 23,100 t in 2009. Brake linings, refractories, and steelmaking were the three industries that dominated U.S. natural graphite use, accounting for 61% of natural graphite consumption. Batteries, foundries, and lubricants accounted for another 8% of natural graphite consumption. The refractories industry was the leading consumer of crystalline flake graphite, accounting for almost 49% of crystalline flake graphite used in 2010.

Graphite has metallic and nonmetallic properties, which makes it suitable for many industrial applications. The metallic properties include electrical and thermal conductivity. The nonmetallic properties include high-thermal resistance, inertness, and lubricity. The combination of conductivity and high-thermal stability allows graphite to be used in many applications, such as in batteries, fuel cells, and refractories. Graphite's lubricity and thermal conductivity make it an excellent material for high-temperature applications because it provides effective lubrication at a friction interface while furnishing a thermally conductive matrix to remove heat from the same interface. Electrical conductivity and lubricity allow its use as the primary material in the manufacture of brushes for electric motors. A graphite brush effectively transfers electric current to a rotating armature while the natural lubricity of the brush minimizes frictional wear. Today's advanced technology products, such as friction materials and battery and fuel cells, require high-purity graphite. Natural graphite is purified to 99.9% carbon content for use in battery applications.

Graphite is made up of parallel sheets of carbon atoms in a hexagonal arrangement. It is possible to insert other atoms between the sheets, a process that is called intercalation. The insertion of other atoms makes dramatic changes in the properties of graphite. Lithium ions can be inserted to create graphite anodes for lithium ion batteries. Graphite can be intercalated with sulfuric and nitric acids to produce expanded graphite from which foils are formed that are used in seals, gaskets, and fuel cells.

Refractory applications of graphite included carbon-bonded brick, castable ramming, and gunning mixtures. Carbon-magnesite brick has applications in high-temperature corrosive environments, such as iron blast furnaces, ladles, and steel furnaces. Carbon-alumina linings are principally used in continuous steel-casting operations. Alumina- and magnesite-carbon brick requires graphite with a particle size of 100 mesh and a purity of 95% to 99%.

Crystalline flake graphite accounted for about 50% of natural graphite usage in the United States. It was consumed mainly in batteries and refractories. Amorphous graphite was mainly used in brake linings, foundries, refractories, steelmaking, and other applications where additions of graphite improve the process or the end product. Lump graphite finds uses in a number of areas, such as steelmaking, depending on purity and particle size.

Synthetic graphite is used in more applications in North America than natural graphite and accounts for a significant share of the graphite market. The main market for high-purity synthetic graphite is as a carbon raiser additive in iron and steel. This market consumes a substantial portion of the synthetic graphite. Other important uses of all types of graphite are in the manufacture of catalyst supports; low-current, long-life batteries; porosity-enhancing inert fillers; powder metallurgy; rubber; solid carbon shapes; static and dynamic seals; steel; and valve and stem packing. The use of graphite in low-current batteries is gradually giving way to carbon black, which is more economical. Graphite is used to manufacture antistatic plastics, conductive plastics and rubbers, electromagnetic interference shielding, electrostatic paint and powder coatings, high-voltage power cable conductive shields, membrane switches and resistors, semiconductive cable compounds, and electrostatic paint and powder coatings.

Graphite has played an important role in the emerging noncarbon energy sector and has been used in several new energy applications. In energy production applications, graphite is used in pebbles for modular nuclear reactors and in high-strength composites for wind, tide, and wave turbines. In energy storage applications, graphite is used in bipolar plates for fuel cells and flow batteries, in anodes for lithium-ion batteries, in electrodes for supercapacitors, in high-strength composites for fly wheels, in phase change heat storage, and in solar boilers. In energy management applications, graphite is used in high-performance polystyrene thermal insulation and in silicon chip heat dissipation. These new energy applications use value-added graphite products, such as high purity, small particle size, potato shape, expanded graphite, and graphene. Current graphite capacity may not be adequate for the increasing demands of these new energy applications, which may require double the current graphite supply when fully implemented (O'Driscoll, 2010).

Prices

Natural graphite prices slowly increased during the second half of 2009 for most types (Industrial Minerals, 2009a). In 2010, graphite prices increased more rapidly especially for crystalline flake graphite, owing to increased demand for graphite used in friction material applications such as brake linings, as a high-quality refractory, as lubricants, and in the manufacturing of graphite foils and long-life alkaline batteries (Industrial Minerals, 2010b).

Prices for crystalline and crystalline flake graphite concentrates ranged from $950 to $2,000 per metric ton; prices for amorphous powder ranged from $430 to $450 per ton (table 4). The average unit value of all U.S. natural graphite exports increased by 43% to $2,720 per ton in 2010 from $1,900 per ton in 2009. Ash and carbon content, crystal and flake size, and size distribution affect the price of graphite. The European port price of synthetic graphite in 2010 ranged from $7,000 to $20,000 per ton. The average unit value of synthetic graphite exports increased by 10% to $3,410 per ton in 2010 from $3,100 per ton in 2009 (table 5).

Foreign Trade

Total graphite exports decreased slightly in tonnage to 45,600 t valued at $152 million in 2010 from 46,400 t valued at $130 million in 2009. Total graphite export tonnage was 12% natural graphite and 88% synthetic graphite (table 5). Total natural graphite imports increased by 98% in tonnage to

65,400 t in 2010 from 33,100 t in 2009, and the value increased by 76% to $52.1 million in 2010 from $29.7 million in 2009 (table 6). This large increase was a result of the graphite industry starting to recover during 2010 from the drastic effects of the global recession on end-use markets, adverse weather in major graphite production areas, and unfavorable regulatory measures in China. Principal import sources of natural graphite were, in descending order of tonnage, China, Mexico, Canada, Brazil, and Madagascar, which combined, accounted for 98% of the tonnage and 91% of the value of total imports. Mexico provided all the amorphous graphite, and Sri Lanka provided all the lump and chippy dust variety. China, Canada, Brazil, Madagascar, and Belgium were, in descending order of tonnage, the suppliers of crystalline flake and flake dust graphite. A number of other producing nations supplied several other natural types and grades of graphite to the United States; among the most notable were Brazil and Canada.

World Review

World production of natural graphite increased by 21% in 2010 to an estimated 925,000 t compared with 762,000 t in 2009. China maintained its position as the world's leading graphite producer, with 600,000 t or 65% of the total. India was the second ranked graphite producer, with 140,000 t, followed by Brazil, North Korea, and Canada, in decreasing order of tonnage produced. These five countries accounted for 94% of world production (table 8).

South Africa became a new graphite producer with the startup of the Jonkel Mine. Jonkel Group produced graphite through its subsidiary, Jonkelkoza Minerals and Resources (Pty) Ltd, and became South Africa's sole graphite producer since Germany's Graphit Kropfmühl AG closed its operations several years ago (Feytis, 2010b).

Outlook

Worldwide demand for graphite is expected to continue increasing as global economic conditions improve. Demand is also expected to continue increasing as more noncarbon energy applications that use graphite are developed.

The trend towards collaboration between Far Eastern and Western graphite producers is expected to continue. These collaborations have been combining superior management, processing, and packaging techniques of Western companies with China's production capabilities located in and adjacent to the largest markets. China offers the optimum cost-location balance. China has made progress in eliminating logistics challenges, such as freight issues, shipping problems, and rising container rates; and the Chinese graphite industry is expected to continue to expand (Moores, 2007; Feytis, 2010a).

Refractory use trends for graphite closely follow events in the steel industry because graphite is used to manufacture refractory brick for lining iron and steel furnaces. The ability to refine and modify graphite is expected to be the key to future growth in the graphite industry. Refining techniques have enabled the use of improved graphite in electronics, foils, friction materials, and lubrication applications. Graphite "freeze" refractories are being developed and tested as an alternative to magnesia refractories for ilmenite smelting by U.S.-based GrafTech International Holdings Inc. This technology uses a furnace lining of thermally conductive graphite and carbon to lower the temperature and remove heat from the furnace lining. Once the temperature drops below the melting point of the molten material in the furnace, a protective slag layer called a "skull" freezes onto the hot face of the refractory lining. Once the slag skull has formed, it extends the life of the lining by insulating the refractories from chemical attacks and thermal shocks (Industrial Minerals, 2009b). Graphite-based refractories also are used as continuous casting ware, usually in the form of nozzles to guide molten steel from ladle to mold. Brake linings and other friction materials are expected to steadily use more natural graphite as new automobile production continues to increase and more replacement parts are required for the increasing number of vehicles. Natural graphite (amorphous and fine flake) is used as a substitute for asbestos in brake linings for vehicles heavier than cars and light trucks. Flexible graphite products, such as grafoil (a thin graphite cloth), are expected to be the fastest growing market but are expected to use small quantities of natural graphite compared to major end-use markets, such as brake linings and refractories. Products produced by advanced refining technology in the next few years, despite a weak refractory market and competitive pricing from Chinese material, could increase profitability in the U.S. graphite industry.

There is also need to double the world's present flake graphite production to satisfy the forecast increased lithium-ion battery demand, particularly in automobiles. Synthetic graphite may offer the most promise for filling that demand (Industrial Minerals, 2009c; 2010a). The expected increase in manufacture and sales of hybrid and electric vehicles is likely to increase demand for high-purity graphite in fuel-cell and battery applications. Fuel cells are a potential high-growth, large-volume graphite (natural and synthetic) end use but are currently a very small part of consumption. High volumes of graphite are not expected to be consumed in this end use for many years but may be used in the longer term (Taylor, 2006, p. 517). In general, the forecasted need to double present graphite supplies to produce value-added graphite products for new energy applications has triggered reopening of shutdown graphite mines and development of graphite resources globally (O'Driscoll, 2010).

Increased global demand for graphite used in batteries will be divided between two main consuming sectors—alkaline batteries and lithium-ion batteries. Synthetic and natural graphite are used in these batteries. In alkaline batteries, graphite is the conductive material in the cathode. Until recently, synthetic graphite was predominantly used in these batteries. With the advent of new purification techniques and more efficient processing methods, it has become possible to improve the conductivity of most natural graphite to the point where it can be used in batteries. The decision of whether to use synthetic or natural graphite will be based on performance and price. The growth of the lithium-ion battery market could have a more dramatic effect on the graphite market as the demand for mobile energy storage systems rises.

There is a common industry trend toward higher purity and consistency in specifications for some specialized and high-tech applications. The trend to produce higher purity graphite using thermal processing and acid leaching techniques continues. High-purity graphite has applications in advanced carbon graphite composites.

The markets for graphite used in rubber and plastics (including Styrofoam coatings) are increasing, and continued growth is expected. The U.S. market for graphite in pencils has almost disappeared; pencil "leads" now are imported directly from China (Taylor, 2006, p. 517). These markets, however, use little graphite and are not expected to have a significant impact on future consumption.

A California-based company was developing a technology that turns carbon dioxide emissions into high-purity synthetic graphite. With the world's industrialized nations pledging to reduce their carbon dioxide emissions by 50% by 2050, this technology could become a promising new synthetic graphite source while helping industrialized nations reach their target goal (Industrial Minerals, 2009d).

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TABLE 1

SALIENT NATURAL GRAPHITE STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Apparent consumption[2]	metric tons	30,400	42,900	50,300	21,700	59,800
Exports:						
Quantity	do.	22,200	15,700	7,950	11,400	5,600
Value	thousands	$16,000	$19,100	$15,600	$21,600	$15,200
Imports for consumption:						
Quantity	metric tons	52,600	58,600	58,300	33,100	65,400
Value	thousands	$29,100	$37,300	$48,100	$29,700	$52,100
World, production[e]	metric tons	1,020,000	1,110,000	962,000 [r]	762,000 [r]	925,000

[e]Estimated. [r]Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits.

[2] Domestic production plus imports minus exports.

TABLE 2

U.S. CONSUMPTION OF NATURAL GRAPHITE, BY END USE[1]

End use	Crystalline		Amorphous[2]		Total	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009:						
Batteries	W	W	--	--	W	W
Brake linings	376	$1,560	2,810	W	3,190	W
Carbon products[3]	257	644	W	W	W	W
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	W	W	W	W
Foundries[4]	W	W	1,420	$6,490	W	W
Lubricants[5]	684	2,120	W	W	W	W
Pencils	W	W	W	W	W	W
Powdered metals	420	1,270	2	5	423	$1,280
Refractories	8,060	6,230	W	W	W	W
Rubber	29	W	W	W	W	W
Steelmaking	W	W	W	W	W	W
Other[6]	5,590	7,950	2,210	13,200	7,800	21,100
Total	16,900	23,300	23,100	95,300	40,000	119,000
2010:						
Batteries	W	W	--	--	W	W
Brake linings	332	1,250	3,040	W	3,380	W
Carbon products[3]	306	929	W	W	W	W
Crucibles, retorts, stoppers, sleeves, nozzles	W	W	W	W	W	W
Foundries[4]	W	W	1,610	8,090	W	W
Lubricants[5]	688	2,150	W	W	W	W
Pencils	W	W	W	W	W	W
Powdered metals	370	1,480	--	--	370	1,480
Refractories	12,500	11,600	W	W	W	W
Rubber	59	W	W	W	W	W
Steelmaking	W	W	W	W	W	W
Other[6]	9,450	16,000	4,320	26,400	13,800	42,500
Total	25,600	37,100	25,700	112,000	51,200	149,000

W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Includes mixtures of natural and manufactured graphite.

[3] Includes bearings and carbon brushes.

[4] Includes foundries (other) and foundry facings.

[5] Includes ammunition and packings.

[6] Includes antiknock and other compounds, drilling mud, electrical/electronic devices, industrial diamonds, magnetic tape, mechanical products, paints and polishes, small packages, soldering/welding, and other end-use categories.

TABLE 3

SHIPMENTS OF SYNTHETIC GRAPHITE BY U.S. COMPANIES, BY END USE[1]

End use	Quantity (metric tons)	Value (thousands)
2009:		
Anodes	W	W
Cloth and fibers (low modulus)	W	$165,000
Crucibles and vessels, refractories	W	W
Electric motor brushes and machined shapes	W	W
Electrodes	80,900	W
High-modulus fibers	W	W
Unmachined graphite shapes	8,680	91,300
Synthetic graphite powder and scrap[2]	W	W
Other	W	W
Total	118,000	998,000
2010:		
Anodes	W	W
Cloth and fibers (low modulus)	W	195,000
Crucibles and vessels, refractories	W	W
Electric motor brushes and machined shapes	W	W
Electrodes	92,100	W
High-modulus fibers	W	W
Unmachined graphite shapes	7,430	96,900
Synthetic graphite powder and scrap[2]	W	W
Other	W	W
Total	134,000	1,070,000

W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] Data are rounded to no more than three significant digits.

[2] Includes lubricants (alone/in greases), steelmaking carbon raisers, additives in metallurgy, and other powder data.

TABLE 4

REPRESENTATIVE YEAREND GRAPHITE PRICES[1]

(Dollars per metric ton)

Type	2009	2010
Crystalline large, 94% to 97% carbon, +80 mesh	1,100–1,350	1,450–2,000
Crystalline large, 90% carbon, +80 mesh	700–800	1,100–1,350
Crystalline medium, 94% to 97% carbon, +100-80 mesh	880–1,150	1,350–1,900
Crystalline medium, 90% carbon, +100-80 mesh	650–750	1,050–1,300
Crystalline medium, 85% to 87% carbon, +100-80 mesh	650–750	1,000–1,400
Crystalline fine, 94% to 97% carbon, +100 mesh	620–1,000	1,250–1,700
Crystalline fine, 90% carbon, -100 mesh	550–600	950–1,300
Amorphous powder, 80% to 85% carbon	430	430–450
Synthetic 99.95% carbon[2]	6,200–19,000	7,000–20,000

[1] Prices are normally cost, insurance, and freight main European port.

[2] European port for 2009 and Swiss border for 2010.

Sources: Industrial Minerals, no. 507, December 2009, p. 68–69; no. 519, December 2010, p. 70.

TABLE 5

U.S. EXPORTS OF NATURAL AND SYNTHETIC GRAPHITE, BY COUNTRY[1,2]

Country	Natural[3] Quantity (metric tons)	Natural[3] Value[5] (thousands)	Synthetic[4] Quantity (metric tons)	Synthetic[4] Value[5] (thousands)	Total Quantity (metric tons)	Total Value[5] (thousands)
2009:						
Canada	1,070	$961	3,230	$7,820	4,300	$8,780
China	1,790	3,210	2,460	8,860	4,250	12,100
France	11	17	3,630	19,000	3,640	19,000
Germany	65	170	1,300	3,360	1,370	3,530
Hong Kong	25	97	125	362	150	460
Italy	100	164	1,080	5,400	1,180	5,570
Japan	473	1,070	1,700	9,970	2,170	11,000
Korea, Republic of	4,490	7,250	1,970	6,400	6,460	13,600
Mexico	1,080	1,290	4,820	6,670	5,910	7,960
Netherlands	28	101	74	151	102	252
Taiwan	85	281	1,590	6,030	1,670	6,310
United Kingdom	265	2,850	657	1,830	922	4,680
Other	1,900	4,160	12,400	32,800	14,300	36,900
Total	11,400	21,600	35,000	109,000	46,400	130,000
2010:						
Canada	1,510	1,470	4,360	13,200	5,870	14,600
China	253	1,250	3,870	16,900	4,130	18,200
France	31	57	2,830	22,200	2,860	22,300
Germany	285	598	1,910	5,220	2,200	5,820
Hong Kong	12	79	74	200	86	279
Italy	198	265	1,190	5,390	1,380	5,660
Japan	728	1,480	1,040	5,280	1,760	6,770
Korea, Republic of	69	610	2,300	9,890	2,370	10,500
Mexico	934	1,080	5,350	7,840	6,290	8,920
Netherlands	16	193	483	911	499	1,100
Taiwan	111	346	2,010	7,820	2,120	8,160
United Kingdom	338	4,240	724	2,550	1,060	6,800
Other	1,110	3,520	13,900	39,100	15,000	42,700
Total	5,600	15,200	40,000	136,000	45,600	152,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Numerous countries for which data were reported have been combined in "Other."

[3] Amorphous, crystalline flake, lump and chip, and natural, not elsewhere classified. The applicable Harmonized Tariff Schedule of the United States (HTS) nomenclatures are "Natural graphite in powder or in flakes" and "Other," codes 2504.10.0000 and 2504.90.0000.

[4] Includes data from the applicable HTS nomenclatures "Artificial graphite" and "Colloidal or semicolloidal graphite," codes 3801.10.0000 and 3801.20.0000.

[5] Values are free alongside ship.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF NATURAL GRAPHITE, BY COUNTRY [1,2]

	Crystalline flake and flake dust		Lump and chippy dust		Other natural crude; high-purity; expandable		Amorphous		Total	
Country	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)	Quantity (metric tons)	Value[3] (thousands)
2009:										
Austria	--	--	--	--	4	$6	--	--	4	$6
Brazil	989	$1,170	--	--	1,860	3,030	--	--	2,850	4,190
Canada	2,150	1,860	--	--	4,180	8,540	--	--	6,330	10,400
China	15,100	9,430	--	--	--	--	--	--	15,100	9,430
Germany	--	--	--	--	72	205	--	--	72	205
Japan	--	--	--	--	105	1,250	--	--	105	1,250
Madagascar	899	839	--	--	--	--	--	--	899	839
Mexico	--	--	--	--	--	--	7,310	$1,820	7,310	1,820
Singapore	--	--	--	--	3	21	--	--	3	21
Switzerland	--	--	--	--	63	350	--	--	63	350
Sri Lanka	--	--	134	$189	--	--	--	--	134	189
United Kingdom	--	--	--	--	173	872	--	--	173	872
Other	--	--	--	--	5	95	--	--	5	95
Total	19,200	13,300	134	189	6,460	14,400	7,310	1,820	33,100	29,700
2010:										
Austria	--	--	--	--	14	25	--	--	14	25
Belgium	16	13	--	--	--	--	--	--	16	13
Brazil	2,420	2,960	--	--	1,520	2,740	--	--	3,940	5,700
Canada	3,150	3,830	--	--	4,960	8,580	--	--	8,110	12,400
China	39,900	25,900	--	--	--	--	--	--	39,900	25,900
Germany	--	--	--	--	208	510	--	--	208	510
India	--	--	--	--	3	11	--	--	3	11
Japan	--	--	--	--	90	2,210	--	--	90	2,210
Madagascar	858	738	--	--	--	--	--	--	858	738
Mexico	--	--	--	--	3	11	11,500	2,950	11,500	2,960
Sri Lanka	--	--	682	1,160	--	--	--	--	682	1,160
Switzerland	--	--	--	--	4	41	--	--	4	41
United Kingdom	--	--	--	--	95	491	--	--	95	491
Other	--	--	--	--	2	28	--	--	2	28
Total	46,400	33,400	682	1,160	6,910	14,600	11,500	2,950	65,400	52,100

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The information framework from which data for this material were derived originated from U.S. Harmonized Tariff Schedule base data.

[3] Customs values.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF GRAPHITE ELECTRODES, BY COUNTRY[1, 2]

Country	Quantity (metric tons)	Value[3] (thousands)
2009:		
Canada	5,160	$30,700
China	12,500	34,100
Germany	1,120	6,750
India	7,410	21,600
Japan	5,980	40,900
Mexico	8,980	24,000
Poland	1,810	7,910
Russia	5,560	15,300
South Africa	418	784
Ukraine	482	1,420
United Kingdom	851	4,930
Other	366 r	1,720 r
Total	50,600	190,000
2010:		
Canada	10,600	56,400
China	15,700	43,400
Germany	2,090	15,400
India	5,280	15,100
Japan	18,000	102,000
Mexico	20,000	58,400
Poland	1,290	5,530
Russia	11,600	31,000
South Africa	1,010	4,070
Ukraine	779	2,160
United Kingdom	1,260	5,590
Other	587	3,090
Total	88,200	342,000

rRevised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The applicable Harmonized Tariff Schedule of the United States (HTS) nomenclature is "Electric furnace electrodes," code 8545.11.0000.

[3] Customs values.

Source: U.S. Census Bureau.

TABLE 8

GRAPHITE: ESTIMATED WORLD PRODUCTION, BY COUNTRY [1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Austria	--	--	250	750	1,000
Brazil, marketable	76,194 [3]	77,163 [3]	76,200 [r, 3]	76,200	76,000 [p]
Canada	28,000	28,000	27,000	25,000	25,000
China	720,000	800,000	650,000 [r]	450,000 [r]	600,000
Czech Republic	5,000	3,000	3,000	--	--
India, run-of-mine[4]	120,000	130,000	140,000	130,000	140,000
Korea, North	30,000	30,000	30,000	30,000	30,000
Korea, Republic of	68 [3]	52 [3]	73 [r, 3]	48 [r]	50
Madagascar	4,857 [3]	5,421 [r]	5,000 [e]	5,000	5,000
Mexico, amorphous	12,500	12,500	7,229 [r, 3]	5,011 [3]	6,759
Norway	2,300	2,000	2,000	2,000	2,000
Romania	--	--	--	20,000 [r]	20,000
Sri Lanka	5,756 [r, 3]	9,593	6,615 [r]	7,000 [r]	8,000
Sweden	800	800	800	800	700
Turkey, run-of-mine[5]	-- [r, 3]	400	3,236 [r, 3]	2,400 [r, 3]	3,000
Ukraine	5,800 [r]	5,800	5,800	5,500 [r]	5,800
Uzbekistan	60	60	60	60	60
Zimbabwe	6,588 [3]	5,418 [r, 3]	5,134 [r, 3]	2,463 [r, 3]	2,000
Total	1,020,000	1,110,000	962,000 [r]	762,000 [r]	925,000

[p]Preliminary. [r]Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 4, 2011.

[3] Reported figure.

[4] Indian marketable production is 10% to 20% of run-of-mine production.

[5] Turkish marketable production averages approximately 5% of run-of-mine production. Almost all is for domestic consumption.

GYPSUM

By Robert D. Crangle, Jr.

Domestic survey data and tables were prepared by Paula R. Neely, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, the United States ranked fourth worldwide in the production of crude gypsum, with 8.84 million metric tons (Mt) of production and a reported value of $60.9 million. China was the world's leading producer and consumer of gypsum, with estimated production of 47 Mt of crude gypsum. As a result of the slowness in recovery of the economy, especially in the residential construction sector, crude production tonnage decreased by approximately 15% from that of 2009, with a corresponding decrease in value of 21% (table 1). Calcined gypsum production decreased by about 9% to 12.1 Mt in 2010 compared with 13.4 Mt produced in 2009.

The sale of synthetic gypsum increased by 32% to 10.7 Mt in 2010 from 8.1 Mt in 2009. The long-term use of synthetic gypsum from flue gas desulfurization (FGD) will likely continue to increase as more coal-fired electric powerplants convert their desulfurization processes to produce marketable gypsum. Many coal-burning powerplants in the United States are required by the U.S. Environmental Protection Agency to install sulfur dioxide scrubbing systems. This created a significant source of byproduct gypsum, at a lower price than the cost of its mined counterpart, which led to the construction of wallboard production facilities adjacent to coal-fired powerplants.

Production

Gypsum industry data for this report are collected by the U.S. Geological Survey (USGS) from semiannual and annual surveys of gypsum operations and from monthly data provided by the Gypsum Association. In 2010, the USGS annual survey canvassed 112 gypsum production operations that accounted for all known domestic output of crude, calcined, and byproduct gypsum. Data were available for all of the operations through this survey, the Gypsum Association, the American Coal Ash Association, or other Federal and State agencies. Some production was estimated on the basis of employment records published by the Mine Safety and Health Administration (MSHA).

The United States was the fourth leading producer of gypsum in 2010, accounting for 6% of reported global output (table 8). During 2010, crude gypsum in the United States was mined by 40 companies at 54 mines in 19 States (table 2). The leading crude gypsum-producing States were, in descending order, Oklahoma, Texas, Iowa, Nevada, and California, which together accounted for 58% of total domestic output.

The U.S. gypsum industry consisted primarily of a few large, vertically integrated companies that mined gypsum and manufactured wallboard, plaster, and other gypsum products. Companies with the most mines were USG Corp. (USG) with eight mines; Georgia Pacific LLC (GP) with seven mines; National Gypsum Co. (NGC) with six mines; CertainTeed Corp. with six mines; American Gypsum with three mines; Temple Inland Inc. (TI) with two mines; and PABCO Gypsum with one mine. For 2010, these seven companies produced 74% of the total U.S. crude gypsum.

During 2010, gypsum was calcined (partially dehydrated by heating) at 62 plants operated by 8 companies in 32 States, principally to produce feedstock for wallboard and plaster manufacturing plants (table 3). The leading gypsum calcining States in 2010 were, in descending order, Texas, California, Florida, Iowa, and Indiana (table 3). These 5 States had 22 plants that produced approximately 4.2 Mt of calcined gypsum and together accounted for about 34% of national output. In 2010, domestic output of calcined gypsum decreased by 9% to 12.1 Mt valued at approximately $360 million (table 1).

In addition to mined gypsum production, synthetic gypsum was generated as a byproduct of various industrial processes. The primary source of synthetic gypsum was FGD from coal-fired electric powerplants. Smaller amounts of synthetic gypsum were derived as a byproduct of chemical processes, such as acid neutralization processes, citric acid production, sugar production from sugar beets, and titanium dioxide production. Synthetic gypsum was used as a substitute for mined gypsum, principally for wallboard manufacturing, cement production, and agricultural purposes, in descending order of importance.

Sixteen synthetic gypsum producers sold 10.7 Mt of synthetic gypsum from their FGD systems during 2010, with an estimated value of $16.1 million. Of the total synthetic gypsum sold and used, 72% was used for wallboard production, 11% was used in cement and concrete manufacture, 8% for mining applications, 4% for agricultural, and the remaining 5% for a variety of other applications. Approximately 51% of synthetic gypsum produced in 2010 was neither sold, nor used, and in most cases was landfilled (American Coal Ash Association, 2011).

For 2010, gypsum-derived products, including agricultural products, cement, plasters, and wallboard totaled 11.7 Mt with a value of $1.68 billion. This represented a production decrease of 16% from the 14.0 Mt produced in 2009, and a 13% decrease in value from $1.9 billion (table 4).

During 2010, eight companies manufactured gypsum wallboard products at 62 plants in the United States. Wallboard product shipments were approximately 17.2 million square feet (1.6 million square meters), a decrease of about 6% compared with those of 2009 (table 5).

The wallboard industry expanded rapidly between 2003 and 2006. American Gypsum, CertainTeed Saint-Gobain, Lafarge North America Inc. (Lafarge NA), National Gypsum, and USG expanded their existing wallboard operations or opened new ones during this time, increasing their wallboard production capacities by more than 1 billion square feet. The decline in the U.S. housing market that began in 2007 and continued through 2010 resulted in flat and declining sales for most gypsum producers, and led to layoffs and the idling of wallboard production plants (Crangle, 2011).

Consumption

In 2010, U.S. apparent domestic gypsum consumption was more than 22.5 Mt, a slight decrease compared with that of 2009. Domestic sources (mined crude plus an estimated 10.7 Mt of synthetic gypsum produced) met approximately 87% of domestic consumption requirements; imports, totaling 3.33 Mt, satisfied the remaining need. In 2010, approximately 48% of the gypsum consumed in the United States came from synthetic sources, 12% more than that which was reported in 2009. An industry-wide shift toward the use of synthetic gypsum continued in 2010. This was largely the result of the lower costs associated with the purchase and transportation of FGD gypsum, which is often available near the same urban centers where wallboard production facilities are located.

Gypsum output is categorized as either calcined or uncalcined (table 4). Calcined gypsum was produced domestically from crude gypsum to manufacture wallboard and plaster products. Uncalcined gypsum, used for portland cement production and agriculture, accounted for virtually all remaining consumption during the year. Miscellaneous uses, such as athletic field markings, accounted for only a fraction of 1% of consumption.

In 2010, about 92% of the calcined gypsum used to manufacture wallboard was consumed in the production of regular ½-inch gypsum board (table 5). This product represented 35% of total calcined gypsum consumption. Type X gypsum board, so named because of extra fire retardation qualities, consumed 35% of calcined gypsum. Other regular gypsum board, from ¼- to 1-inch thick, consumed 3% of the total. Other wallboard, including lath, mobile-home wallboard, predecorated wallboard, sheathing, veneer base, and water- and moisture-resistant wallboard, composed most of the balance. Metropolitan areas in the South Atlantic, West South Central, East North Central, Middle Atlantic, and Pacific (in decreasing order) were the leading sales areas for gypsum wallboard products.

As a result of the economic downturn and the associated reduction in the construction industry's demand for concrete, uncalcined gypsum consumed in the United States decreased by 5% in 2010 to 1.28 Mt. About 901,000 t, or 71%, of the uncalcined gypsum consumed in the United States was for Portland cement production (table 4). Gypsum is added to cement to retard its setting time and makes up about 2% to 4% by weight of cement output (Roskill Information Services Ltd., 2009, p. 320). Most of the remainder of the uncalcined gypsum consumed, about 375,000 metric tons (t), was used primarily for agricultural purposes. Agricultural use of gypsum increased by 7% from that of 2009. Finely ground gypsum rock was used in agriculture and other industries to neutralize acidic soils, to improve soil permeability, to add nutrients, to stabilize slopes, and to provide catalytic support for maximum fertilizer benefits. Small amounts of high-purity gypsum are also used in a wide range of industrial applications, including the production of foods, glass, paper, and pharmaceuticals.

Recycling

Gypsum waste generated by the wallboard manufacturing process may be recycled. The gypsum core and paper covering are separated, then reinjected with new material into the manufacturing stream.

Several million tons of gypsum waste is generated every year by building demolition, wallboard installation, and wallboard manufacturing. Because labor expenses are higher than wallboard prices, construction costs are lowered when full pieces of uncut wallboard are used in place of multiple, smaller remnants. As a result, between 10% and 12% of the wallboard used in new construction and renovation is discarded as scrap. Only a small portion of this waste has been recycled. On December 14, 2010, the Massachusetts Department of Environmental Protection banned the disposal of clean wallboard from State waste disposal facilities (Massachusetts Department of Environmental Protection, 2010). As landfill space becomes more scarce, recycling is expected to increase. In addition to recycling scrap in wallboard plants, wallboard scrap may also be ground and used as a soil conditioner.

Wallboard manufacturers and the construction industry have been exploring ways to return scrap wallboard and waste wallboard to plants for recycling. Other potential markets for recycled gypsum include cement production, as a stucco additive, sludge drying, water treatment, grease absorption, and for marking athletic fields. Until costs and legislation associated with landfilling scrap gypsum become more restrictive, recycling will likely continue to remain a low priority within the industry.

Prices

In 2010, the average values (free on board, mine or plant) reported by U.S. producers were $6.89 per metric ton for crude gypsum and $29.65 per ton for calcined gypsum (table 1). The average value for plaster reported by domestic producers during the year was $345 per ton (table 4). The average value of uncalcined gypsum used primarily for agricultural purposes was approximately $52.26 per ton and that used in cement production was about $17.21 per ton (table 4).

During 2010, prices for gypsum wallboard increased by 6% despite an 18% decrease in total wallboard production (table 5). This is likely a result of the wallboard industry adjusting to market conditions following several years of declining production. The combined average price of ½-inch wallboard for 20 major U.S. metropolitan cities in 2010 was $248.56 per 100 square meters ($230.92 per 1,000 square feet). From January 2010 to January 2011, prices for ½-inch regular wallboard decreased by 5%, while Type X wallboard increased slightly, in 20 major U.S. metropolitan cities (Engineering News-Record, 2010; 2011).

Average ½-inch wallboard prices during 2010 were lowest in St. Louis, MO, ($109 per 100 square meters or $102 per 1,000 square feet), followed by Detroit, MI, ($115 per 100 square meters or $107 per 1,000 square feet), and

Cleveland, OH, ($129 per 100 square meters or $120 per 1,000 square feet). The highest average wallboard prices in 2010 were in Boston, MA, ($409 per 100 square meters or $380 per 1,000 square feet), followed by Philadelphia, PA, ($309 per 100 square meters or $287 per 1,000 square feet) and San Francisco, CA, ($298 per 100 square meters or $277 per 1,000 square feet) (Engineering News-Record, 2011).

Foreign Trade

In 2010, the United States led the world in international trade in gypsum and gypsum products (tables 6–7). The United States imported crude gypsum from 12 countries and exported gypsum and gypsum products to 86 countries and territories, although only a small quantity of crude gypsum and other gypsum products were exported by the United States in 2010, most of which went to Canada.

Imports of crude gypsum in 2010 decreased by 21% from those of 2009 and accounted for 13% of apparent consumption. Much of this import dependence can be attributed to the lack of adequate domestic gypsum resources near large east coast and west coast wallboard markets. Canada and Mexico accounted for 94% of imported gypsum, while imports from Spain supplied most of the remainder. The majority of imports from Canada went to east coast plants, while Mexican sources chiefly served the west coast. Foreign subsidiaries of U.S. gypsum companies produced much of the gypsum that was imported for their respective U.S.-based wallboard plants. Most of the crude gypsum imported by the United States from Mexico was produced by Compania Minera Caopas, S.A. de C.V. and Compania Occidental Mexicana S.A. de C.V. in Baja California Sur, both of which operate mines on the Baja California Peninsula (Compania Occidental Mexicana S.A. de C.V., 2005; Compania Minera Caopas, S.A. de C.V., 2010). Almost all gypsum imported from Canada came from Nova Scotia. The completion of large wallboard manufacturing plants near powerplants along the east coast may reduce gypsum imports in the future.

Wallboard exports increased by nearly 10% in 2010, totaling about 729,000 metric tons valued at $129 million. Ninety-five percent of board exports went to Canada. Wallboard imports increased by 4% in 2010, totaling 244,000 t valued at $32.4 million.

World Industry Structure

Global crude gypsum production in 2010 was estimated to be 147 Mt, representing a slight decrease compared with that of 2009, when production totaled 150 Mt (table 1). In 2010, 87 countries produced gypsum, 10 of which accounted for 74% of the total world production (table 8). An estimated 250 million metric tons per year of synthetic gypsum (mostly phosphogypsum) was generated worldwide (Roskill Information Services Ltd., 2009, p. 22). Much of the synthetic production, however, was disposed of rather than used. China was the leading producer of crude gypsum in 2010 with an estimated 47 Mt, followed by Iran with 13.0 Mt, Spain with 11.5 Mt, the United States with 8.8 Mt, Thailand with 8.5 Mt, Japan with 5.7 Mt, and Italy with 4.1 Mt. Although its crude gypsum reserves are substantial, the available Iranian crude production data predate the global recession, as well as several years of international sanctions that intensified in 2006. These conditions degraded Iran's economy and were accompanied by a rise in both unemployment and inflation, which may have led to a decline in residential and commercial construction and a corresponding decrease in gypsum consumption (Fassihi, 2010). Furthermore, since 2009, most Iranian banks have been prohibited from extending loan assistance toward the purchase of property, which has likely further hampered residential construction, and with it, gypsum production (Guillaume and Sensenbrenner, 2011). Consequently, the available gypsum production data for Iran may not be accurate.

Given the expansion in China's economy and its respective construction and infrastructure demands, China will likely continue to be the world's leading gypsum producer for the near future. North American production accounted for 10% of total crude gypsum production. Although the use of gypsum wallboard increased worldwide, only industrialized nations used gypsum primarily for wallboard products. In developing countries, especially in Asia and the Middle East, most gypsum was used in the production of cement or plaster products. World production may have been underestimated, because output by some foreign gypsum producers was used to manufacture products onsite, which may not have been reported. Additionally, production from small deposits in developing nations was intermittent and in many cases unreported.

Worldwide, the leading use of gypsum is in the manufacture of cement and concrete. In 2008 (the last year worldwide end use was available), cement manufacture accounted for up to 60% of worldwide gypsum consumption, while plaster products, including wallboard, accounted for approximately 30% of all consumption (Roskill Information Services Ltd., 2009, p. 320, 330).

As a low-value, high-bulk commodity drawn from deposits widely distributed throughout the world, gypsum tended to be consumed within the many countries where it was produced. Less than 20% of the world's crude gypsum production was estimated to enter international trade. Only a few countries, such as Canada, Mexico, Spain, and Thailand, were major crude gypsum exporters; of these, Canada and Mexico were significant exporters because of their large deposits proximate to wallboard markets in the United States. Compared to imports, little crude gypsum was exported from the United States (tables 1, 7).

Estimated world production capacity for gypsum wallboard in 2010 exceeded 17 billion square meters per year (about 183 billion square feet per year) at more than 250 plants worldwide. Approximately 20% of this capacity was in the United States; Asia and Western Europe each accounted for about 20% of capacity.

World Review

Asia.—A significant increase in commercial and residential construction and infrastructure additions and improvements, coupled with a cultural shift toward the use of more gypsum-based products, resulted in a continuation of increased gypsum consumption. From 2002 through 2008, the production of crude gypsum in Asia has increased 2% faster than the rate of economic growth, as the acceptance and use of wallboard and plaster products has increased faster than the region's gross domestic product (GDP) (Roskill Information Services Ltd., 2009, p. 18). Yoshino

Gypsum Co. Ltd., which opened Japan's first plasterboard factory in 1921, owned 16 wallboard plants throughout Japan in 2010 with a combined production capacity of 486 million square meters per year (Global Gypsum Magazine, 2010c).

Europe.—Lafarge Group (France) reported increased sales of 10% in the second quarter of 2010, with higher volumes compensating for reduced prices (Global Gypsum Magazine, 2010d). With 77 gypsum plants in 30 countries and nearly 8,000 employees, LaFarge was the third ranked gypsum producer in the world in 2010 (Lafarge Group, 2011, p. 3). Saint-Gobain (France) announced plans to open new gypsum plants in Algeria, China, Egypt, and Russia, which will add to its Gypsum Activity unit that employed nearly 12,000 employees in 130 production facilities throughout the world in 2010 (Saint-Gobain Group, 2011, p. 7, 17). The privately owned and operated Knauf Group (Germany) operated 40 wallboard and 110 plaster and building materials plants in 49 countries in 2010. During that same period, Knauf was the second leading foreign investor in the Commonwealth of Independent States (CIS) countries with an estimated 7,500 employees throughout the CIS (Global Gypsum Magazine, 2010b).

Middle East.—Most countries in the Middle East consumed all domestically produced gypsum, with the exception of Iran, which annually exported more than 1 Mt (Roskill Information Services Ltd., 2009, p. 17).

South America.—In 2010, Lafarge and co-owner Etex Group, operated wallboard plants in Argentina, Brazil, Chile, and Colombia as well as plaster plants in Brazil and Chile (Lafarge, 2011, p. 36). Brazilian Gypsum, which represented 95% of Brazil's overall production, exported gypsum to markets in Angola, Aruba, France, India, Iraq, Italy, Jordan, Mercosul, Nicaragua, Portugal, Spain, the United Kingdom, the United States, and Venezuela (Brazilian Gypsum, 2010).

Australia.—Australian housing construction activity increased by 22% in 2010 to 169,000 new-home starts, which followed a 40-year low of 139,000 starts in 2009 (Housing Industry Association of Australia, 2011). Perhaps in response to the improved economic circumstances associated with residential construction, Boral Ltd., Australia's leading building and construction materials producer, invested $80 million in its Australian plasterboard business. Revenue from Boral's Building Products division, which includes all of its gypsum-associated products, was up by 6% in 2010 to a total of $1.2 billion (Boral Ltd., 2010, p. 8, 18).

Canada.—Canadian production of crude gypsum totaled 2.72 Mt, a 23% decline from the 3.54 Mt produced in 2009, which represented a 38% decline from that of 2008. About 1.98 Mt, or 73% of Canadian production, was exported to the United States. NuGyp, a new wallboard and plasters manufacturing technique developed by Innogyps, Inc., was named the 2010 best new product of the year by Global Gypsum, the industry's leading trade association, for significantly reducing water demand and energy costs associated with wallboard and special plasters production (Pro Publications, 2010).

China.—In 2010, Beijing New Building Materials (BNBM), the largest gypsum-board producer in Asia, operated 21 wallboard plants in China with an estimated annual production of 1 billion square meters (Global Gypsum Magazine, 2010b). Lafarge planned to invest $21 million in two new wallboard production facilities, each with a capacity of 15 million square meters, and each supplied with synthetic gypsum from the Chongqing Luohuang coal-fired powerplant (Global Gypsum Magazine, 2010e).

The issue of corrosive imported wallboard from China into the United States continued to be problematic. The U.S. Consumer Product Safety Commission received approximately 3,900 reports of possible corrosive wallboard from residents in 43 States, the District of Columbia, American Samoa, and Puerto Rico (U.S. Consumer Product Safety Commission, 2010). Sulfide gases emitted from the problematic drywall were suspected of damaging copper wiring and plumbing, while also raising human health concerns (Global Gypsum Magazine, 2010a). Following several years of complaints regarding corrosive wallboard imported from China, a pending class-action settlement was reached in a Louisiana Federal Court in 2011. The proposed agreement between approximately 5,000 affected homeowners, most of whom reside in Gulf Coast and southern United States, and Chinese wallboard manufacturer, Knauf Plasterboard Tianjin, could reach $1 billion (Wotapka, 2011).

Mexico.—In 2010, gypsum production in Mexico was 3.56 Mt, a 38% decrease from that of 2009. About 1.14 Mt, or 32% of Mexico's 2010 crude gypsum production, was exported to the United States. In 2010, USG Mexico S.A. de C.V., the largest manufacturer of wallboard in Mexico, increased sales by $9 million, or 6%, compared with those of 2009, despite a production decrease of 12%, the result of beneficial currency exchange rates (USG Corp., 2011, p. 34).

Outlook

U.S. demand for gypsum products was expected to increase during the next 2 to 3 years as housing starts are projected to rise (Irwin, 2011). Because the residential housing market is responsible for approximately 60% of the consumption of gypsum products, a key economic indicator used by the gypsum and wallboard industries is the number of new housing starts, as measured by the issuance of new building permits. Since 1959, the average number of annual housing starts, including multidwelling units, is 1.5 million per year (Zibel and Bater, 2011). Although annual housing starts of 1.8 million (and greater) were not sustainable during the pre-2008 recessionary years, neither were the 554,000 nor the 587,000 housing starts of 2009 and 2010, respectively (U.S. Census Bureau, 2011). As the surplus of residential real estate dwellings constructed before 2009 is drawn down, the Nation's annual population growth of 3 million new persons, alone, may necessitate an increase in residential construction within the near future (U.S. Census Bureau, 2008; Irwin, 2011; Zibel and Bater, 2011).

The availability of FGD gypsum was expected to continue to increase as new scrubbers come online at more coal-fired electric powerplants (U.S. Environmental Protection Agency, 2010). During the next several years, the use of mined gypsum may continue to decline in the United States as greater quantities of synthetic gypsum are used in wallboard manufacturing. Some actual and planned gypsum mine closings have already been attributed to the increased availability of synthetic gypsum. This increased use of synthetic gypsum could accelerate additional mine closings through 2020. This changeover, however, will likely be limited to FGD plants with close proximities to wallboard production facilities, or where new wallboard plants will be constructed adjacent to existing FGD plants. The percentage of synthetic gypsum use may eventually reach an economic equilibrium point. In the long term, as disposal areas fill and the opening of new disposal sites becomes increasingly difficult, power companies may have to calcine, clean, or subsidize the transportation costs associated with synthetic gypsum in order to dispose of excess waste. This may increase the economic viability of using FGD gypsum from powerplants that are presently considered too far from wallboard plants.

Expansion of synthetic gypsum production facilities will continue in the United States. Forecasts indicate that demand for high calcium limestone, the primary component required to transform sulfur dioxide to synthetic gypsum in many FGD processes, could increase by about 70% during the next 10 years as existing and new coal-fired powerplants are fitted with FGD scrubbing systems to meet Clean Air Act regulatory requirements (Industrial Minerals, 2008). Approximately 85% of FGD systems are wet scrubbers that use a limestone slurry to capture sulfur dioxide emissions (Industrial Minerals, 2009). The trend toward FGD gypsum as a raw material, at the expense of crude gypsum, is expected to continue as air pollution regulations become more stringent within the United States and throughout the industrialized world.

The U.S. gypsum industry has been moving toward the use of large-capacity wallboard plants supplied from multiple sources, including synthetic gypsum from coal-fired powerplants. These larger wallboard plants have been built in regions of high population and growth, which are the areas of highest consumption. The older, less efficient, and smaller natural (mined) gypsum-fed plants will find it increasingly difficult to compete, and some likely will close. As a response to increased public awareness, the gypsum industry may boost the recycling of scrap gypsum into its raw materials streams. The industry may also increase the use of ecolabels, such as the Scientific Certification System Green Cross, which certifies the presence of recycled and recovered content in each product.

Worldwide industry trends indicate significant developments abroad in the coming decade. The pace and magnitude of wallboard plant construction in Asia, particularly China, India, and Thailand, suggest that the continent, with billions of potential consumers, will probably become one of the world's leading gypsum wallboard markets. Should the economic conditions in the United States more favorably affect the U.S. housing sector, and in turn increase the U.S. consumption of gypsum, Canadian gypsum production should likewise increase. Elsewhere, wallboard production capacity increases and the recognition in Central America, Europe, India, and South America of the convenience and economy of wallboard as a building material means that wallboard manufacturing may require increased gypsum production in future years.

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TABLE 1

SALIENT GYPSUM STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2006	2007	2008	2009	2010
United States:					
Crude:					
Production:					
Quantity	18,600	15,700	12,300	10,400	8,840
Value	107,000	95,000	91,200	77,400	60,900
Imports for consumption	11,400	9,390	7,330	4,220	3,330
Synthetic gypsum sales	8,670	8,370	9,660	8,120	10,700
Calcined:					
Production:					
Quantity	21,600	21,700	17,900	13,400 r	12,100
Value	716,000	768,000	674,000	478,000 r	360,000
Products sold, value	4,260,000	3,610,000	2,500,000	1,850,000	1,620,000
Exports, value	36,700	43,600	47,400	37,800	42,200
Imports for consumption, value	5,010	6,700	7,240	6,800	7,180
World, production	160,000	167,000 r	156,000 r	150,000 r	147,000 e

eEstimated. rRevised.

[1] Data are rounded to no more than three significant digits.

TABLE 2

CRUDE GYPSUM MINED IN THE UNITED STATES, BY STATE[1]

	2009			2010		
State	Active mines	Quantity (thousand metric tons)	Value (thousands)	Active mines	Quantity (thousand metric tons)	Value (thousands)
Arizona, Colorado, New Mexico	8	1,410	$10,500	8	1,180	$8,140
Nevada and Utah	7	1,460	10,900	7	1,270	8,720
Arkansas, Kentucky, Louisiana	4	670	4,990	4	547	3,770
California and Washington	6	1,310	9,740	6	850	5,860
Iowa and Indiana	10	1,780	13,300	10	1,540	10,600
Michigan and West Virginia	3	539	4,010	3	478	3,290
South Dakota and Wyoming	4	316	2,350	4	272	1,870
Kansas, Oklahoma, Texas	12	2,920	21,700	12	2,710	18,600
Total	54 r	10,400	77,400	54	8,840	60,900

rRevised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 3

CALCINED GYPSUM PRODUCED IN THE UNITED STATES, BY STATE[1]

	2009			2010		
State	Active plants	Quantity (thousand metric tons)	Value (thousands)	Active plants	Quantity (thousand metric tons)	Value (thousands)
Alabama, Kentucky, Tennessee	4	1,040	$37,400	4	988	$29,300
Arizona, Colorado, Nevada, New Mexico, Utah, Wyoming	10	2,240	80,200	10	2,040	60,600
Arkansas, Louisiana, Texas	9	1,810	65,000	9	1,690	50,100
California, Oregon, Washington	8	1,680	60,300	8	1,500	44,400
Florida, Georgia, North Carolina, South Carolina	7	1,610	57,600	7	1,470	43,600
Illinois, Indiana, Michigan	6	1,150	41,300	6	1,010	29,900
Iowa, Kansas, Oklahoma	7	1,440	51,600	7	1,330	39,500
Maryland, Pennsylvania, Virginia, West Virginia	7	1,380	49,600	7	1,180	34,900
New Hampshire, New Jersey, New York	4	986	35,300	4	918	27,200
Total	62 r	13,400 r	478,000 r	62	12,100	360,000

rRevised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4

GYPSUM PRODUCTS (MADE FROM DOMESTIC, IMPORTED, AND SYNTHETIC GYPSUM) SOLD OR USED IN THE UNITED STATES, BY USE[1]

(Thousand metric tons and thousand dollars)

Use	2009		2010	
	Quantity	Value	Quantity	Value
Uncalcined:				
Portland cement	992	15,400	901	15,500
Agriculture and miscellaneous[2]	352	19,500	375	19,600
Total	1,340	34,900	1,280	35,100
Calcined:				
Plasters	83	27,700	80	27,300
Prefabricated products[3]	12,600	1,850,000	10,400	1,620,000
Total	12,700	1,880,000	10,400	1,640,000
Grand total	14,000	1,920,000	11,700	1,680,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes synthetic gypsum.

[3] Includes weight of paper, metal, or other materials and some synthetic gypsum.

TABLE 5

PREFABRICATED GYPSUM PRODUCTS SOLD OR USED IN THE UNITED STATES[1]

Product	2009			2010		
	Quantity (thousand square feet)	Quantity[2] (thousand metric tons)	Value (thousands)	Quantity (thousand square feet)	Quantity[2] (thousand metric tons)	Value (thousands)
Lath:						
$^3/_8$-inch	--	--	--	W	W	W
$^1/_2$-inch	--	--	--	--	--	--
Other	29,900	27	$4,020	--	--	--
Total	29,900	27	4,020	W	W	W
Veneer base	202,000	147	21,100	203,000	149	$19,800
Sheathing	390,000	283	48,400	327,000	238	42,000
Regular gypsumboard:						
$^3/_8$-inch	467,000	270	46,100	414,000	147	25,900
$^1/_2$-inch	8,360,000	5,360	817,000	8,790,000	4,290	640,000
$^5/_8$-inch	329,000	267	58,800	38,500	26	4,000
1-inch	58,600	51	7,940	38,000	35	5,490
Other[3]	260,000	170	46,800	293,000	144	33,300
Total	9,470,000	6,120	977,000	9,570,000	4,640	708,000
Type X gypsumboard	6,550,000	4,860	561,000	5,560,000	4,190	619,000
Predecorated wallboard	58,700	43	18,800	60,200	44	18,800
$^5/_{16}$-inch mobile home board	202,000	119	23,700	104,000	62	13,600
Water- and moisture-resistant board	1,140,000	835	174,000	1,140,000	835	166,000
Other	213,000	187	26,900	224,000	200	27,500
Grand total	18,300,000	12,600	1,850,000	17,200,000	10,400	1,620,000

W Withheld to avoid disclosing company properietary data. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes weight of paper, metal, or other materials.

[3] Includes $^1/_4$-, $^7/_{16}$-, and $^3/_4$-inch gypsumboard.

TABLE 6
IMPORTS FOR CONSUMPTION OF CRUDE GYPSUM, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2009 Quantity	2009 Value	2010 Quantity	2010 Value
Canada[2]	2,720	38,500	1,980	26,000
Mexico	1,340	12,700	1,140	11,800
South Africa	--	--	8	951
Spain	164	1,640	198	2,940
Other	(3)	65	(3)	170
Total	4,220	52,900	3,330	41,800

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes anhydrite.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7
U.S. GYPSUM AND GYPSUM PRODUCTS FOREIGN TRADE[1]

(Thousand metric tons and thousand dollars)

Year	Crude[2] Quantity	Crude[2] Value	Plasters[3] Quantity	Plasters[3] Value	Boards[4] Quantity	Boards[4] Value	Other, value[5]	Total, value
Exports:								
2009	156	16,000	155	37,800	665	120,000	50,200	224,000
2010	360	19,300	190	42,200	729	129,000	66,200	257,000
Imports for consumption:								
2009	4,220	52,900	15	6,800	236	38,500	30,300	128,000
2010	3,330	41,800	15	7,180	244	32,400	29,600	111,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Data are for "Gypsum, anhydrite," Harmonized Tariff Schedule of the United States (HTS) code 2520.10.0000.

[3] Data are for "Plasters," HTS code 2520.20.0000.

[4] Data are for "Boards, sheets, panels, tiles, and similar articles, not ornamented—Faced or reinforced with paper or paperboard only," HTS code 6809.11.0000.

[5] Data are for "Boards, sheets, panels, tiles, and similar articles, not ornamented: Other," HTS code 6809.19.0000, and "Other articles," HTS code 6809.90.0000.

Source: U.S. Census Bureau.

TABLE 8

GYPSUM: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2006	2007	2008	2009	2010[e]
Afghanistan[e]	2	2	2	2	2
Algeria	1,033	1,198	1,672	1,700	1,700 [3]
Argentina	1,203	1,227	1,257	1,300	1,360
Armenia	44	55	46	45	45
Australia	4,265	3,896	3,500 [e]	3,500 [e]	3,500
Austria, gypsum and anhydrate	1,071	1,064	1,087	911 [r]	1,000
Azerbaijan	35	22	38 [r]	46 [r]	48 [3]
Bhutan	160	189 [r]	248 [r]	248 [r]	250
Bolivia	1	4	4	2 [r]	1 [3]
Bosnia and Herzegovina	132	154	150	74 [r]	80
Brazil[4]	1,712	1,884 [r]	2,239 [r]	2,348 [r]	2,350 [p]
Bulgaria[4]	216	234	210 [r, e]	190 [r, e]	190
Burma	69	75	82	98	81 [3]
Canada[4]	9,036	7,562	5,740	3,540	2,717 [3]
Chile	845	773	774	724	725
China[e]	42,000	48,000	46,000	45,000	47,000
Colombia	186	200	200	190 [e]	200
Croatia	170	335	330 [r]	234 [r]	240
Cuba[e]	(5)	(5)	(5)	(5)	(5)
Cyprus[e]	250 [3]	250	250	250	250
Czech Republic	16	66	35 [e]	13	5
Dominican Republic	161	146	185	175	175
Ecuador[e]	1 [3]	2	1	1	1
Egypt[e, 4]	2,000 [e]	3,007	2,381	2,500	2,400
El Salvador[e]	6	6	6	6	6
Eritrea[e]	1 [3]	1	1	1	1
Ethiopia[4]	39	30	33	33 [e]	33
France[e, 4]	4,800	4,800	2,339 [3]	2,300	2,300
Germany, marketable[4]	1,771	1,898	2,112	1,898	1,822 [3]
Greece[e, 4]	500	500	500	500	500
Guatemala	227	495	127	19	50
Honduras[e]	6	6	6	6	6
Hungary[e, 4]	30	26	26	24 [r]	24
India[e]	2,450	2,500	2,550	2,600	2,650
Indonesia[e]	6	6	6	6	6
Iran[e, 6]	12,000	12,000	12,000	13,000	13,000
Ireland[e]	450	450	450	450	450
Israel	111	83	10	9 [r]	10
Italy	2,860	5,459	4,139	4,130 [e]	4,130
Jamaica	364	228	238	230 [e]	230
Japan	5,796	5,850	5,800 [e]	5,750	5,700
Jordan	334	288	300 [e]	300 [e]	300
Kenya[4]	9	10	10	10 [e]	10
Laos[e]	775 [3]	775	775	775	775
Latvia[e]	230 [3]	230	230	230	230
Lebanon[e]	70 [r]	80 [r]	85 [r]	100 [r]	105
Libya[e]	200	240	250	250	250
Luxembourg[e, 4]	(5)	(5)	(5)	(5)	(5)

See footnotes at end of table.

TABLE 8—Continued
GYPSUM: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country	2006	2007	2008	2009	2010[e]
Macedonia	268	256	242	155	160
Mauritania	45	49	44	37 [r]	45
Mexico[4]	6,076	6,080 [e]	5,135	5,757	3,560 [3]
Moldova	186	312	701 [r]	164 [r]	164
Mongolia[e]	26	NA	NA	NA	NA
Morocco[e]	600	600	600	600	600
Nicaragua[e, 4]	42 [3]	40	40	40	40
Niger	13	5	9	9 [e]	9
Nigeria[e]	169	579	300	300 [e]	350
Oman	254 [r]	183 [r]	349 [r]	254 [r]	395 [3]
Pakistan	650	703 [r]	700 [r]	650	600
Paraguay[e]	5	5	5	5	5
Peru	151	335	335 [e]	355	335
Poland[4]	1,353	1,492	1,481 [r]	1,299 [r]	1,300
Portugal[e, 4]	400 [3]	400	300	300	300
Romania	615	707	885 [r]	800 [e]	600
Russia[e]	2,600	3,000	3,600	2,900 [3]	2,900
Saudi Arabia[e]	2,101 [3]	2,100	2,300	2,100	2,100
Serbia[e]	45	45	45	45	45
Slovakia[4]	126	151	152	131 [r]	135
South Africa	554	627	571	598	517 [3]
Spain[e, 4]	11,500 [3]	11,500	11,500	11,500	11,500
Sudan[4]	7 [e]	8	13 [r]	30 [r, e]	30
Switzerland[e]	250	250	250	250	25
Syria	444	448	573	403	450
Tajikistan[e]	9 [3]	9	9	26 [r]	15
Tanzania[4]	33	53	56 [r]	8 [r]	30
Thailand	8,355	8,643 [r]	8,500 [e]	8,500 [e]	8,500
Tunisia[e]	151	157	177 [r]	360 [r]	360
Turkey	4,370	3,241	3,000 [e]	3,100 [e]	3,200
Turkmenistan[e]	100	100	100	100	100
Uganda[e]	(5) [3]	(5)	(5)	(5)	(5)
Ukraine	376	742	1,158	711 [r]	710
United Arab Emirates[e]	130	150	200	200	150
United Kingdom[e, 4]	1,700 [3]	1,700	1,700	1,700	1,700
United States[7]	18,600	15,700	12,300	10,400	8,840 [3]
Uruguay[e]	5	5	5	5	5
Venezuela	7 [3]	7	7	7	7
Yemen	44	45	50 [e]	50 [e]	65
Total	160,000	167,000 [r]	156,000 [r]	150,000 [r]	147,000

[e] Estimated. [p] Preliminary. [r] Revised. NA Not available.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 31, 2011.

[3] Reported figure.

[4] Includes anhydrite.

[5] Less than ½ unit.

[6] Data are for years beginning March 21 of that stated.

[7] Excludes byproduct gypsum.

HELIUM

By Joseph B. Peterson[1] and Peter J. Madrid[2]

Sales of Grade-A helium (99.995% or greater purity) by private industry were 51.2 million cubic meters[1] (about 1.85 billion cubic feet) in the United States in 2010, and exports by private producers were 76.8 million cubic meters (about 2.77 billion cubic feet) for total sales of about 128 million cubic meters (about 4.61 billion cubic feet) of U.S. helium, a 8.4% increase from that of 2009 (table 1). During 2010, domestic helium sales increased by 10.1%, while helium exports increased by 8% compared with those of 2009.

Legislation and Government Programs

The Helium Privatization Act of 1996, Public Law 104.273 (The Act), directed the Federal Helium Program to discontinue production and sale of refined helium by April 9, 1998. The Act also directed the Government to offer for sale the helium stored in the Federal helium reserve, in excess of 600 million cubic feet, between January 1, 2005, and January 1, 2015.

The Act called for a National Academy of Sciences (NAS) study to determine the impact of selling the reserve using the pricing mechanism described in the Act. The first study was completed in 1998. Operational problems experienced by the helium plants in Algeria and Qatar during 2005 and the continued increase of helium exports from the United States have had an impact on pricing (helium suppliers increased the price of helium) and availability of cryogenic helium (helium supplies were disrupted), in particular to the scientific community. During 2009, the NAS initiated a second study to reevaluate the impact of selling the reserve under the existing pricing mechanism to determine whether adjustments were needed that would optimize future availability of helium for its many scientific and industrial uses. The second study was completed in January 2010, and recommendations by the NAS were being reviewed by the Bureau of Land Management (BLM) personnel at yearend.

The final provision of the legislation to be implemented was the disposal of the Exell Helium Plant. In June 2010, the Texas Commission on Environmental Quality and the U.S. Environmental Protection Agency (EPA) issued a ready for reuse (RFR) certificate for the property, and the property was sold in December 2010.

Production

In 2010, 13 companies operated 19 of 22 privately owned domestic helium plants, 13 of which extracted helium from natural gas. Two of the crude helium plants did not produce or extract helium during 2010, one Grade-A helium plant did not produce helium in 2010, and no new helium plants came online in 2010. All but two extraction plants used cryogenic extraction processes. Total sales of U.S.-produced helium in 2010 increased by about 8.4% compared with those of 2009. All natural gas processed for helium recovery came from gas fields in Colorado, Kansas, Oklahoma, Texas, Utah, and Wyoming (figure 1). During 2010, 10 private plants purified helium by using pressure swing adsorption technology. Eight privately owned plants that produced Grade-A helium also liquefied helium. The plant operators and plant locations are listed in table 2.

Domestic production data for helium were developed by the BLM from records of its own operations as well as from its high-purity helium survey, an annual voluntary canvass of private U.S. operations. Of the eight operations to which a survey request was sent, all responded, and those data plus data from BLM operations represent 100% of the total helium sales and recovery data listed in table 3.

About 8.4% more helium was produced from the Government's helium reserve at Cliffside Field in 2010 than during 2009. Most domestic helium production comes from the Midcontinent and Rocky Mountain regions of the United States. The measured helium reserves from which helium is produced are located in approximately 102 gas fields in 11 States. Most of these reserves are contained in the Hugoton Field in Oklahoma, Kansas, and Texas; the Panoma Field in Kansas; the Keyes Field in Oklahoma; the Panhandle West and Cliffside Fields in Texas; and the Riley Ridge area in Wyoming.

During 2010, the BLM analyzed 18 natural gas samples from 5 States in conjunction with its program to survey and identify possible new sources of helium. During the past 2 years, considerable efforts were focused on digitizing the information in the helium resources database, with the goal of producing an updated map of helium reserves in the United States by 2012.

Consumption

In 2010, private industry supplied 100% of domestic helium consumption. The major domestic end uses of helium were cryogenics (26.0%), controlled atmospheres (22.0%), pressurizing and purging (17.0%), welding (17.0%); other uses included chromatography/lifting gas/heat transfer (12.0%), leak detection (4.0%), and synthetic breathing mixtures (2.0%) (Figure 3). In cryogenics, magnetic resonance imaging applications dominated liquid helium use. Estimated 2010 domestic consumption by end use was based on revised figures for a 2009 end-use survey conducted by BLM's Helium Operations to determine trends in helium usage.

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[3] All metric helium volumes herein are at 101.325 kilopascals absolute (14.696 pounds per square inch absolute) and 15 °C (59 °F). Helium volumes, reported in parentheses following metric units, are measured in cubic feet at 14.7 pounds per square inch absolute and 70 °F—1,000 cubic feet (14.7 pounds per square inch absolute and 70 °F) equals 27.737 cubic meters (101.325 kilopascals absolute and 15 °C) and 1 cubic meter (101.325 kilopascals and 15 °C) equals 36.053 cubic feet (14.7 pounds per square inch absolute and 70 °F).

In 2010, U.S. domestic helium consumption increased 8.4% to 51.2 million cubic meters (about 1.85 billion cubic feet) compared with consumption for 2009. During 2010, U.S. helium exports increased 8% to 76.8 million cubic meters (about 2.77 billion cubic feet), compared with those of 2009 (table 1).

In-kind crude helium sales regulations (43 CFR part 3195) require helium refiners that sell helium to Federal agencies and their contractors to buy an equivalent amount of crude helium from the BLM. In 2010, in-kind crude helium sales were about 4.88 million cubic meters (175.9 million cubic feet). The sales were made to eight companies through contracts with the BLM.

Stocks

The volume of helium stored in the BLM helium conservation storage system, including the conservation pipeline network and the Cliffside Field, totaled about 465 million cubic meters (about 16.8 billion cubic feet) on December 31, 2010. The storage system contained crude helium purchased under contract by the Government from 1962 to 1973 and privately owned helium extracted by industry from natural-gas-supplying fuel markets and stored under contract. This privately owned helium is returned to the owners as needed for purification to supply private demand. During 2010, 12.4 million cubic meters (447 million cubic feet) of privately owned helium was delivered to the BLM's helium conservation system, and 65.2 million cubic meters (about 2.35 billion cubic feet) were withdrawn, for a net decrease of 52.8 million cubic meters (about 1.90 billion cubic feet) of private helium in storage (table 4).

Transportation

Private producers and (or) distributors shipped helium, predominantly as a liquid, in semitrailers, which delivered the liquid helium to distribution centers, where some of it was gasified and compressed into trailers and small cylinders for delivery to end users. The remaining liquid helium was sold as bulk liquid or repackaged in Dewars of various sizes for delivery.

Prices

In fiscal year 2010, the price that the BLM charged private companies for crude helium was \$2.33 per cubic meter (\$64.75 per thousand cubic feet), about 4% higher than that of 2009. The BLM crude helium price is set by the helium Act of 1996 and is adjusted yearly based on the Consumer Price Index for the previous year.

Foreign Trade

In 2010, exports of Grade-A helium increased to 76.8 million cubic meters (2.77 billion cubic feet), an 8% increase compared with those of 2009, and accounted for about 51.2% of sales of U.S.-produced helium; private industry supplied all U.S. helium exports. The increase in helium exports was attributed to increased shipments of helium to Australia, Belgium, Brazil, Canada, Germany, Republic of Korea, and Singapore. About 50% of the helium exported from the United States went to Asia, with Japan receiving about 20% of total U.S. exports. About 25% of the exported helium was shipped to Europe; collectively, Belgium, France, Germany, Italy, and the United Kingdom received 94% of the helium exported to Europe. Other export destinations and percentages received were Canada and Mexico, combined, 14%; South America, 8%; Australia and New Zealand, 1%; the Middle East and Africa, 1% each; Central America, and the Caribbean, less than 1% each. For 2010, import tariffs on helium remained at 3.7% for normal trade relations (NTR) nations and 25% for non-NTR nations.

World Review

Excluding the United States, world production capacity of helium was estimated to be about 70 million cubic meters (2.53 billion cubic feet) for 2010 (table 5). During 2010, the helium market began to slowly recover from the economic downturn of 2008–09. Helium production levels were 20% to 25% higher than in 2009. Two new plants in the Riley Ridge, WY, area started construction during 2010. Worldwide, several new helium plant projects were scheduled for startup sometime during 2012–18. Other new plants were to be constructed in Algeria, Australia, Indonesia, Qatar, and Russia. All known helium that was produced outside the United States during 2010 was extracted in Algeria, Australia, Poland, Qatar, and Russia.

Outlook

From 2005–10, the total sales of U.S. produced helium increased about 2% per year, while from 2000–10; the average growth rate was near zero. Owing to the slow U.S. economic recovery, U.S. domestic helium consumption is expected to increase only slightly during 2011. Foreign helium demand also is expected to increase slightly during 2011. With the anticipation that foreign helium production will remain stable during 2011, increased foreign demand is expected to result in increased U.S. helium exports of about 5% compared with 2010 exports.

GENERAL SOURCES OF INFORMATION

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Helium Resources of the United States, 2001. U.S. Bureau of Land Management Technical Note 408, 2001.

Helium Resources of the United States, 2003. U.S. Bureau of Land Management Technical Note 415, 2004.

Helium Resources of the United States, 2007, U.S. Bureau of Land Management Technical Note 429, 2009.

TABLE 1
TOTAL SALES OF GRADE-A HELIUM PRODUCED IN THE UNITED STATES[1]

(Million cubic meters)

	Volume		
Year	Domestic sales	Exports[2]	Total sales
2006	75.2	61.9	137
2007	73.5	64.2	138
2008	59.6	69.9	130
2009	46.5	71.1	118
2010	51.2	76.8	128

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Source: U.S. Census Bureau.

TABLE 2
OWNERSHIP AND LOCATION OF HELIUM EXTRACTION PLANTS IN THE UNITED STATES IN 2010

Owner or operator	Location	Product purity
Air Products Helium, Inc.	Hansford County, TX	Grade–A helium.[1]
Do.	Liberal, KS	Do.
BP America Production Co.	Sunray, TX	Crude helium.
Do.	Ulysses, KS	Do.
DCP Midstream	Cheyenne Wells, CO	Crude and Grade–A helium.[1]
Do.	Hansford County, TX	Crude helium.
Do.	Liberal, KS	Do.
Do.	Borger, TX	Do.
EnCana Oil & Gas (USA) Inc.	Moab, UT	Crude and Grade–A helium.[1]
ExxonMobil Gas Marketing Co.	Shute Creek, WY	Do.
IACX Energy[2]	Otis, KS	Crude helium.
K-L Energy Partners, LLC[3]	Lakin, KS	Do.
Linde Global Helium, Inc.	Otis, KS	Grade–A helium.[1]
Midstream Energy Services, LLC[4]	Keyes, OK	Crude and Grade–A helium.[1]
Nacogdoches Oil & Gas[5]	Shiprock, NM	Grade–A helium.
ONEOK, Field Services[3]	Bushton, KS	Crude helium.
ONEOK, Field Services[6]	Scott City, KS	Do.
Pioneer Natural Resources Co.	Fain, TX	Do.
Do.	Satanta, KS	Do.
Praxair, Inc.	Bushton, KS	Grade–A helium.[1]
Do.	Ulysses, KS	Do.
SemGas, L.P.[7]	Dodge City, KS	Crude helium.

Do. Ditto.

[1] Including liquefaction.

[2] Plant came online May 2009.

[3] Plant did not produce helium during 2010.

[4] Midstream Energy Services, LLC purchased plant from Nathaniel Energy in March 2009.

[5] Nacagdoches Oil & Gas Shiprock Helium Plant did not produce helium during 2010.

[6] Output is piped to Ulysses, KS, for purification.

[7] Plant shut down April 2009.

TABLE 3
HELIUM RECOVERY IN THE UNITED STATES[1]

(Thousand cubic meters)

	2006	2007	2008	2009	2010
Crude helium:					
Bureau of Land Management (BLM) sold (in-kind and open market)	63,500	58,800	50,300	30,200	66,000
Private industry:					
Private helium accepted and stored by BLM	18,100	15,800	21,600	15,800	12,400
Helium withdrawn from storage	-75,800	-76,500	-71,500	-55,400	-65,200
Total net helium put into storage	-57,700	-60,700	-49,900	-39,600	-52,800
Grade-A helium:					
Private industry sold	137,100	137,700	129,500	117,600	149,800
Total helium stored	-57,700	-60,700	-49,900	-39,600	-52,800
Helium recovery from natural gas	79,400	77,000	79,600	78,000	97,000

[1] Negative numbers denote a net withdrawal from BLM's underground storage facility, a partially depleted natural gas reservoir at the Cliffside Field near Amarillo, TX.

TABLE 4
SUMMARY OF BUREAU OF LAND MANAGEMENT HELIUM CONSERVATION STORAGE SYSTEM OPERATIONS[1, 2]

(Thousand cubic meters)

	2008	2009	2010
Helium in conservation storage system on January 1:			
Stored under BLM conservation program[3]	583,500	532,500	500,500
Stored for private producers under contract	27,600	28,000	18,600
Total[3]	611,100	560,500	519,100
Input to system:			
Net deliveries from BLM plants	--	--	--
Stored for private producers under contract	21,600	15,800	12,400
Total[3]	21,600	15,800	12,400
Redelivery of helium stored for private producers under contract	-71,500	-55,400	-65,200
Net addition to system[3]	-49,900	-39,600	-52,800
Helium in conservation storage system on December 31:			
Stored under BLM conservation program[3]	532,500	500,500	433,000
Stored for private producers under contract	28,000	18,600	31,800
Total[3]	560,500	519,100	464,800

-- Zero.

[1] Crude helium is injected into or withdrawn from BLM's underground storage facility, a partially depleted natural gas reservoir at the Cliffside field near Amarillo, TX.

[2] Negative numbers denote a net withdrawal from BLM's storage facility.

[3] Net additions to system do not include in-kind crude sales or transfers. Totals, however, do include crude sales and transfers.

TABLE 5
WORLD GRADE–A HELIUM ANNUAL PRODUCTION CAPACITY AS OF DECEMBER 31, 2010

(Million cubic meters)

	Capacity
United States[1]	177
Rest of world[e]	70
Total[e]	247

[e] Estimated.

[1] Includes plants on standby as well as operating plants.

FIGURE 1
MAJOR U.S. HELIUM-BEARING NATURAL GAS FIELDS

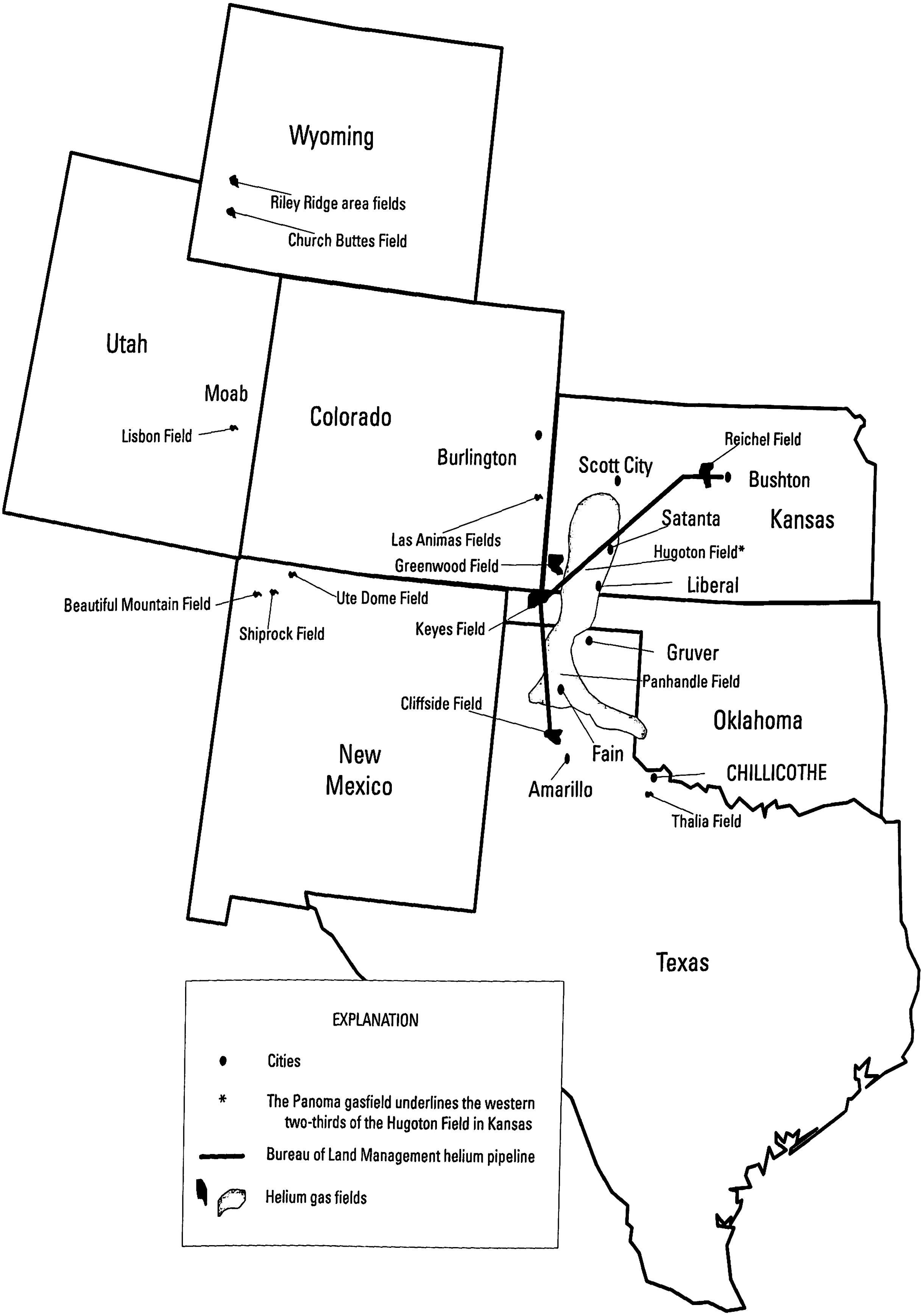


FIGURE 2
HELIUM RECOVERY IN THE UNITED STATES

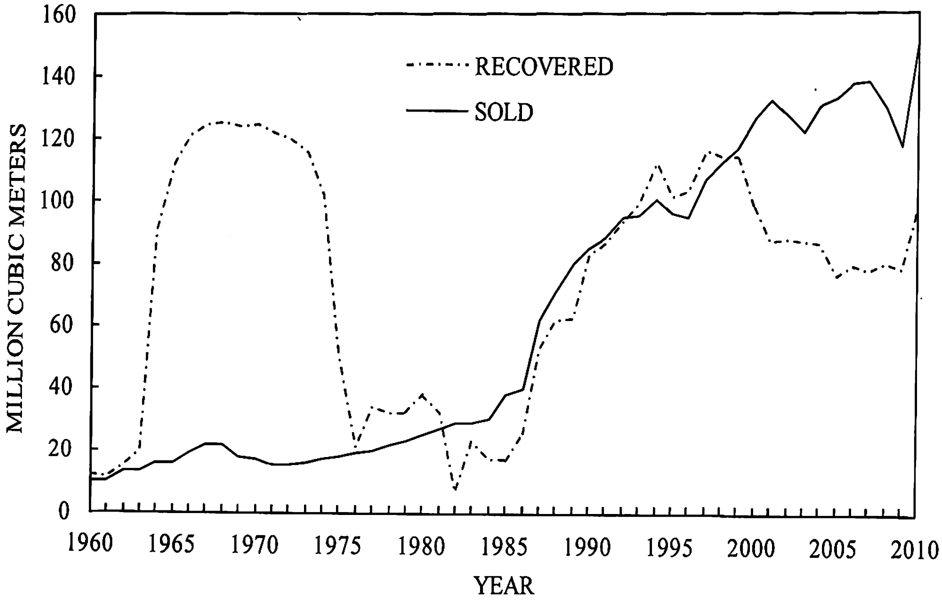
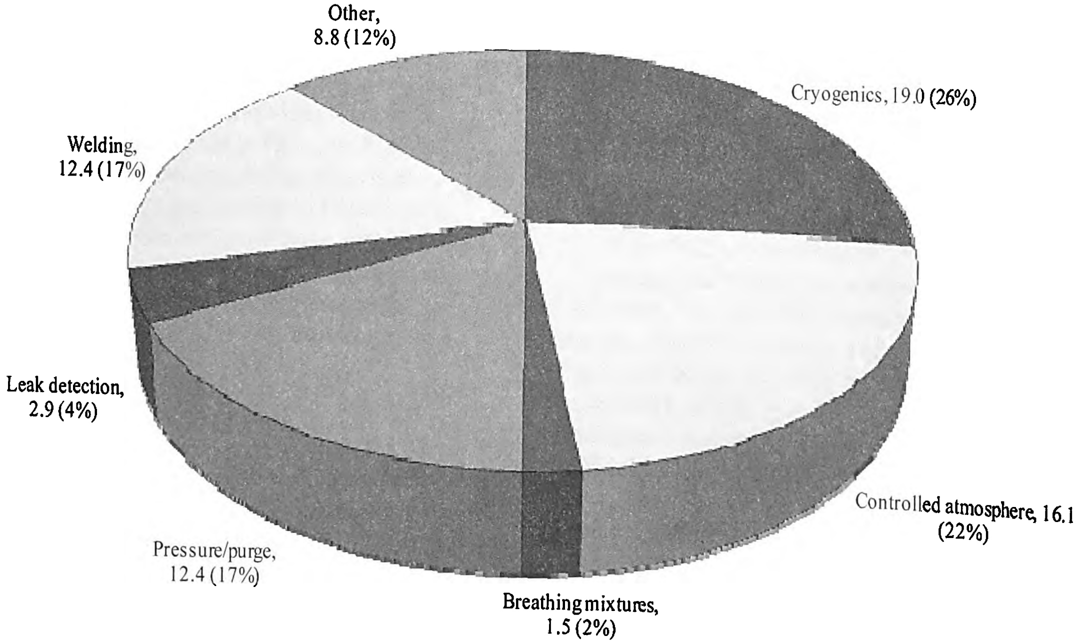


FIGURE 3
ESTIMATED HELIUM CONSUMPTION, BY END USE,
IN THE UNITED STATES IN 2010[1]



[1] Total helium used in the Unites States in 2010 was estimated to be 73.2 million cubic meters.

IODINE

By Marc A. Angulo

Domestic survey data and tables were prepared by Cheryl J. Crawford, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Iodine production and apparent consumption in the United States increased in 2010 compared with that of 2009. Data for production and apparent consumption were withheld to avoid disclosing company proprietary data. Reported consumption by producers and consuming industries was 4,670 metric tons (t) in 2010 compared with 4,550 t in 2009. Crude and sublimed iodine exports decreased to 1,070 t valued at $22.3 million in 2010 compared with 1,160 t valued at $22.9 million in 2009. Imports of crude iodine increased to 5,710 t valued at $141 million in 2010 compared with 5,190 t valued at $133 million in 2009. World production, excluding United States production, was estimated to be 28,700 t in 2010 compared with 28,500 t in 2009.

Legislation and Government Programs

In 2008, the U.S. Environmental Protection Agency (EPA) approved the restricted use of the soil fumigant iodomethane (methyl iodide) as an alternative to the ozone depleting methyl bromide. Companies must provide training for employees and satisfy risk mitigation requirements set by the EPA. Respirators or ducted fan and blower systems must be used by workers applying the fumigant. Tarps must be placed over treated fields, and buffer zones must be established around fields where the fumigant will be applied. Use of the fumigant is prohibited within a specified distance from such sites as day care facilities, nursing homes, prisons, and schools. Methyl iodide can be used to control insects, nematodes, plant pathogens, and weeds and may be used on crops, turf, and plants such as ornamentals, peppers, strawberries, tomatoes, trees, and vines. The EPA concluded three field studies conducted in Georgia, Florida, and Michigan, consisting of human health risk assessments and emission studies of iodomethane applied to fields using impermeable tarps, and found that emission were significantly reduced compared to typical processes. Once an evaluation of data from these field studies is concluded, changes to iodomethane labels will likely be made (U.S. Environmental Protection Agency, 2011).

Production

The U.S. Geological Survey obtained domestic production data for iodine from a voluntary canvass of two U.S. operations (table 1). U.S. production increased slightly in 2010 from that of 2009. Data were withheld to avoid disclosing company proprietary data.

IOCHEM Corp. (a subsidiary of Toyota Tsusho America, Inc.) produced iodine near Vici, in Dewey County, OK. Woodward Iodine Corp. (owned by Ise Chemical Corporation of Japan) produced iodine near Woodward, in Woodward County, OK.

Iofina plc (United Kingdom) completed development of its Atlantis prospect in northern Montana, which included drilling its first production well, construction of iodine and gas separation buildings, and laying a 14.5-kilometer (km)-long gas pipeline extension. The prospect consists of sodium chloride brine with high concentrations of iodine, located between two major biogenic gas fields. After several delays owing to mechanical issues, collection of gas and iodine at the prospect began in March (Iofina plc, 2008, 2010).

Consumption

U.S. apparent consumption of iodine, which is withheld to avoid disclosing company proprietary data, increased by 12% in 2010 from that of 2009. Reported consumption by consuming industries was 4,670 t in 2010 compared with 4,550 t in 2009. Accurate end-use statistics are difficult to gather since domestic and imported iodine were used to produce many intermediate iodine compounds, usually by downstream manufacturers. However, 16 of the 22 companies to which a survey form was sent responded to the annual or preliminary surveys, representing 74% of the total consumption by major domestic users of iodine (tables 1, 2).

Use of iodine in manufacturing increased by 3% in 2010 compared with that of 2009 (table 2). Production of crude iodine and potassium iodide (KI) decreased by about 59% and 27%, respectively. Two companies accounted for the bulk of the decrease in use of crude iodine and KI. Production of miscellaneous and other inorganic iodine products, which includes cuprous iodide and potassium iodate, increased by 12%. Production of organic iodine compounds decreased by 10%.

Commercial crude iodine normally has a minimum purity of 99.5% to 99.8%, depending on the supplier. Impurities, in order of quantity, are primarily insoluble materials, iron, sulfuric acid, and water. The U.S. Pharmacopeia specifies an iodine content of not less than 99.8% for commercial iodine. The Committee on Analytical Reagents of the American Chemical Society allows a maximum of 0.005% total bromine and chlorine and 0.010% nonvolatile matter in its specifications for iodine.

Biocides and Disinfectants.—Since iodine is one of the most effective medical antiseptics available, it was used in biocides and disinfecting chemicals. Iodophors, water soluble chemical complexes designed to carry large amounts of iodine, were incorporated into disinfectants for use in dairies, food processing plants, hospitals, and laboratories. The National Aeronautics and Space Administration (NASA) uses iodine in its water disinfection process on all manned space flights and in the international space station. Iodine is a cost-efficient, effective, and simple means of water disinfection.

Catalyst.—Iodine catalysts were used to manufacture acetic acid and synthetic rubbers. Acetic acid was used in the manufacture of certain adhesives, dyes, pharmaceuticals, plastics, surface coating, and vinegar. Most acetic acid is produced using the methanol carbonylation process, which uses iodomethane at an intermediate step. Catalysts were generally recycled and reused in new processes.

A research team from Japan developed a metal-free way to create the compound 2,3-dihydrobenzofuran, used in a variety of biologically active drugs, by employing iodine as a way to sidestep the use of toxic heavy metals. This catalytic process was considered environmentally friendly since no heavy metal waste products were produced (Everts, 2010).

Chemicals.—Iodine was used as a stabilizer in the manufacture of nylon for tire cord and carpets and for converting resins, tall oil, and other wood products to a more stable form.

Nutrition.—Iodine is an essential component of thyroid hormones, which directly affect processes in the brain, muscles, heart, pituitary gland, and kidneys. Iodine deficiency causes goiter in adults, increased mortality and impaired cognitive development in children, and reproductive failure. Iodine deficiency disorder can be prevented by consuming about 150 milligrams of iodine per day for a human adult (Institute of Medicine of the National Academies, 2006).

Pharmaceuticals.—Radiopaque agents, drugs that absorbs x rays, are used to help diagnose certain medical ailments and may contain iodine. Radiopaque-diagnosed medical problems include brain disorders, cardiac disease, central nervous system disorders, cerebrospinal fluid, disk disease, gastrointestinal (gall bladder) disorders, peritoneal disorders, splenic and portal vein disorders, urinary track disorders, and vascular disease. Potassium iodide was used as an expectorant in cough medicines. Hydriodic acid and KI were used in the synthesis of amphetamine, ethylamphetamine, and methamphetamine, which are regulated stimulants. The isotope I-131 was used to treat thyroid cancer and hyperthyroidism.

Other Uses.—Developments in digital imaging have allowed electronic prints and overhead transparencies to be produced without the need for wet processing film. The majority of current feature films, however, relied on printed film for shooting since film provides higher image resolution. In the next decade, uses of iodine in films and processing may be limited to specialty film imaging as digital imagery technology for motion pictures improves and digital equipment and printers become more affordable.

Using iodine as a radiocontrast agent in x-ray imaging has been found to increase the risk of kidney failure and should be used with caution on patients with impaired kidney function (Tung, 2006). Barium sulfate, which was used primarily in digestive system imaging, can be used as an iodine substitute but is also known to cause complications. Many elements have higher atomic numbers than iodine; however, no other element has the chemical characteristics that allow iodine to form soluble compounds with low toxicity. It is this latter property which makes iodine-containing contrast media suitable for radiography.

Iodine is used for manufacturing iodine-adsorbed polyvinyl alcohol polarizing films for liquid crystal displays (LCD) for electronic equipment, including appliances, computers, digital cameras, personal handheld devices, and televisions. Polarizers are added to LCDs to enhance the light contrast between the screen and the liquid crystals, making the LCD more visible. These polarizers are usually made from stretched polyvinyl alcohol films that contain iodine.

Prices

Prices for iodine and its derivatives continued to increase in 2010. The average free alongside ship (f.a.s.) value for exported crude iodine in 2010 was $20.81 per kilogram, an increase from $19.75 per kilogram in 2009. The average declared cost, insurance, and freight (c.i.f.) value for imported crude iodine was $24.71 per kilogram in 2010, a decrease from $25.54 per kilogram in 2009. The average declared c.i.f. value for iodine imported from Chile, the leading source country of imported iodine for the United States, was $25.45 per kilogram in 2010 compared with $26.66 per kilogram in 2009. The average declared c.i.f. value for imported crude iodine from Japan was $21.06 per kilogram in 2010, an increase from $19.90 per kilogram in 2009.

The spot price of crude crystal iodine, 99.5% minimum purity, in 50-kilogram drums delivered to the United Kingdom ranged from $30.80 to $31.80 per kilogram in January 2010. In December, the price increased to $31 to $33 per kilogram (Industrial Minerals, 2010a, b). Actual prices for iodine are negotiated on long- and short-term contracts between buyers and sellers.

Foreign Trade

Net trade is not easily defined since iodine was exported and imported in many forms other than elemental iodine and KI. Exports of crude iodine decreased to 1,070 t with an f.a.s. value of $22.3 million in 2010 compared with 1,160 t valued at $22.9 million in 2009 (table 3). Exports of KI increased to 442 t with an f.a.s. value of $9.3 million in 2010 compared with 128 t valued at $2.7 million in 2009. Exports of crude iodine to Canada, Germany, and Mexico represented 86% of total crude iodine exports in 2010.

Imports of crude iodine increased to 5,710 t with a c.i.f. value of $141 million in 2010 compared with 5,190 t valued at $133 million in 2009 (table 4). Imports of KI increased to 423 t with a c.i.f. value of $9.8 million in 2010 compared with a total of 259 t valued at $6 million in 2009. Imports of crude iodine from Chile and Japan represented more than 99% of total crude iodine imports in 2010.

World Review

World production of iodine, excluding the United States, was estimated to be 28,700 t in 2010 compared with 28,500 t in 2009 (table 5). Chile was the world's leading producer of iodine, followed by Japan and the United States.

World consumption of iodine and its derivatives was estimated to be 30,000 t in 2010, a 17% increase from 25,500 t in 2009. Production from Chile accounted for 58% of that tonnage; Japan accounted for 21%; and the United States accounted for 5%. Other producing countries accounted for 2% of the iodine supply, and iodine recycled in the manufacturing process accounted for 14%. X-ray contrast media represented 20%, iodophors represented 13%, pharmaceuticals represented 13%, and LCD represented 11% of iodine consumption in 2010 (Sociedad Química y Minera de Chile S.A., 2011a, p. 11). An estimated 16% of iodine may be consumed in manufacturing industrial catalysts (Kanto Natural Gas Development Co., Ltd., undated).

Azerbaijan.—Azeryod LLC (a subsidiary of ISR Holding) continued expansion of its Neftchala iodine plant, supported by a $15 million loan from the European Bank for Reconstruction and Development (European Bank for Reconstruction and Development, 2010). In late 2009, construction was completed on a 10-km-long collector linking the Khilly field with the Azeryod plant, and two 15,000-cubic-meter reservoirs were repaired (ISR Holding, 2010). In 2010, the company received warnings from the Ministry of Ecological and Natural Resources in connection with environmental pollution at the Neftchala plant. After an examination, it was determined that a leak existed in a tank which received iodine from the wells, and the Ministry instructed the company to resolve the deficiencies (Today.az, 2010).

Chile.—Sociedad Química y Minera de Chile S.A. (SQM), the leading iodine producer in Chile, reported sales of 11,900 t of iodine and iodine derivatives valued at $316 million in 2010 compared with 7,200 t valued at $191 million in 2009. The increase in sales was attributed to increased demand in industrial applications, such as LCD screens and biocides (Sociedad Química y Minera de Chile S.A., 2011b). SQM estimated that it held 36% of the world market for iodine and its derivatives (Sociedad Química y Minera de Chile S.A., 2011a).

Atacama Minerals Corp., a publicly held Canadian company operating the Aguas Blancas mine in northern Chile, commissioned an agitated leaching processing plant in late 2008 with the intent of increasing production to 1,500 metric tons per year (t/yr) of iodine from 1,000 t/yr. The $26.5 million plant was expected to increase recovery of iodine to more than 75% from 55%, reduce processing time from several months to less than 24 hours (reducing the need for new heap-leach pad construction), and reduce water consumption by 25%. However, full startup was delayed since the crushing and grinding section of the plant was inadequate to handle the higher than expected sodium sulfate levels found in the mine. In late 2009, the company announced plans to reconfigure the crushing and grinding circuit to adequately handle the various ore types. In the second quarter of 2010, design details were finalized, and construction was expected to be completed in January 2011 (Atacama Minerals Corp., 2008, 2009, 2010).

Outlook

The Chilean producers, which produced 58% of the global iodine supply in 2010, were operating near capacity and were expected to expand production in response to changes in demand and to capitalize on expected increases in iodine prices. SQM projected global demand to increase to 31,000 t and prices to increase to $34 per metric ton in 2011 (Sociedad Química y Minera de Chile S.A., 2011a). The water treatment market was expected to increase, with more growth anticipated in Asia. Expanding treatment of municipal water supplies could increase the demand for biocides and disinfectants in the future. Use of x-ray contrast media, which contain as much as 60% iodine, was expected to increase. More medical tests on an aging population could result in increased demand for iodine-containing x-ray contrast media.

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TABLE 1
SALIENT IODINE STATISTICS[1]

(Metric tons and dollars)

	2006	2007	2008	2009	2010
United States:					
Production	W	W	W	W	W
Imports:					
Quantity, for consumption[2]	5,640	6,060	6,300	5,190	5,710
Price, average[3] dollars per kilogram	19.34	21.01	21.52	25.55	24.71
Exports[2]	1,580	1,060	950	1,160	1,070
Consumption:					
Reported[4]	4,570	4,470	4,590	4,550	4,670
Apparent[5]	W	W	W	W	W
World, production[e]	26,700	26,300	26,500	28,500	28,700

[e] Estimated. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Source: U.S. Census Bureau information reported by Harmonized Tariff Schedule of the United States code 2801.20.0000.

[3] Cost, insurance, and freight valuation.

[4] Reported by voluntary response to the U.S. Geological Survey from a survey of domestic establishments.

[5] Calculated using domestic production plus imports minus exports plus adjustments for government and domestic industry stock changes.

TABLE 2
DOMESTIC CONSUMPTION OF IODINE, BY PRODUCT [1, 2]

	2009		2010	
Product	Number of plants	Quantity (metric tons)	Number of plants	Quantity (metric tons)
Inorganic compounds:				
Crude iodine	7	505	3	207
Resublimed iodine	7	62	7	699
Potassium iodide	4	167	4	122
Sodium iodide	5	193	1	10
Hydriodic acid	3	195	3	181
Potassium iodate	3	17	3	34
Miscellaneous iodate, and iodides[3]	2	37	1	93
Other inorganic compounds	5	510	4	752
Total	XX [4]	1,690	XX [4]	2,100
Organic compounds:				
Ethylenediamine dihydroiodide	2	231	2	256
Povidine-iodine (iodophors)	2	321	--	--
Other organic compounds[5]	7	2,310	9	2,320
Total	XX [4]	2,860	XX [4]	2,580
Grand total	XX	4,550	XX	4,670

XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Reported by voluntary response to the U.S. Geological Survey in a survey of domestic establishments.

[3] Includes ammonium iodide, calcium iodate, and cuprous iodide.

[4] Nonadditive because some plants produce more than one product concurrently.

[5] Includes methyl and (or) ethyl iodide and other unspecified products.

TABLE 3

U.S. EXPORTS OF CRUDE IODINE AND POTASSIUM IODIDE, BY COUNTRY OF ORIGIN[1]

	2009		2010	
Type and country of origin[3]	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Iodine, crude/resublimed:				
Argentina	8	$76	2	$24
Canada	154	3,570	203	4,920
Costa Rica	8	8	--	--
Egypt	5	144	4	104
El Salvador	6	42	--	--
Germany	779	15,300	661	14,000
Italy	90	2,180	35	940
Japan	14	222	28	509
Malaysia	2	13	9	64
Mexico	67	854	55	319
Netherlands	--	--	10	221
South Africa	(4)	6	33	551
United Arab Emirates	--	--	9	235
Other[5]	26 r	471 r	24	420
Total	1,160	22,900	1,070	22,300
Potassium iodide:[6]				
Australia	6	164	14	338
Chile	--	--	82	1,730
France	29	792	119	2,600
Germany	(4)	3	35	862
Korea, Republic of	12	108	25	452
Mexico	10	297	13	370
Russia	--	--	5	125
Saudi Arabia	--	--	31	702
Taiwan	40	610	73	1,030
Turkey	8	245	16	451
Other[7]	23 r	497 r	30	673
Total	128 r	2,720 r	442	9,330

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Declared free alongside ship valuation.

[3] Export information for crude and resublimed iodine and potassium iodide are reported by Harmonized Tariff Schedule of the United States codes 2801.20.0000 and 2827.60.2000, respectively.

[4] Less than ½ unit.

[5] Includes countries with quantities less than 10 metric tons.

[6] Potassium iodide contains 76% crude iodine.

[7] Includes countries with quantities less than 5 metric tons.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS OF CRUDE IODINE AND POTASSIUM IODIDE FOR CONSUMPTION, BY COUNTRY OF ORIGIN[1]

	2009		2010	
Type and country of origin[3]	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Iodine, crude:				
Chile	4,290	$114,000	4,770	$121,000
France	7	187	1	13
India	19	615	--	--
Japan	871	17,300	937	19,700
Other[4]	2	25	4	45
Total	5,190	133,000	5,710	141,000
Potassium iodide:[5]				
Brazil	22	471 [r]	19	415
Canada	183	4,560	315	8,000
Chile	35	632 [r]	26	337
Germany	3	47	9	110
India	8	188	35	663
United Kingdom	8	95	15	166
Other[4]	(6) [r]	2 [r]	3	82
Total	259	6,000	423	9,770

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Declared cost, insurance, and freight valuation.

[3] Import information for crude iodine and potassium iodide are reported by Harmonized Tariff Schedule of the United States codes 2801.20.0000 and 2827.60.2000, respectively.

[4] Includes countries with quantities less than 5 metric tons.

[5] Gross potassium iodide contains 76% crude iodine.

[6] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5
CRUDE IODINE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Azerbaijan	300	300	300	300	300
Chile[3]	16,494 [4]	15,473 [4]	15,503 [4]	17,399 [4]	17,500
China	560	570	570	580	590
Indonesia	75	75	75	75	75
Japan	8,724 [4]	9,282 [4]	9,500	9,600	9,700
Russia	300	300	300	300	300
Turkmenistan	270	270	270	270	270
United States	W	W	W	W	W
Uzbekistan	2	2	2	2	2
Total	26,700	26,300	26,500	28,500	28,700

W Withheld to avoid disclosing company proprietary data; not included in total.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 23, 2011.

[3] Includes iodine production reported by Servicio Nacional de Geologia y Minería.

[4] Reported figure.

INDIUM

By Amy C. Tolcin

The domestic table was prepared by Maria Arguelles, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

All refined indium produced in the United States during 2010 came from the refining of lower grade imported indium metal and from refining of scrap. Two refineries, one in New York and the other in Rhode Island, produced the majority of indium metal and indium compounds in 2010. A number of smaller companies produced specialty indium alloys and other indium products.

Production

Though zinc was mined domestically, primary indium was not known to be recovered from these zinc concentrates. Lithic Resources Ltd. (Vancouver, British Columbia, Canada), however, completed a preliminary economic assessment for its Crypto zinc-copper-indium project in Utah in August. The assessment concluded that the deposit would be developed as an underground mine with an onsite mill that would produce zinc-indium and copper-gold-silver concentrates. The mill would be designed to process 3,500 metric tons per day of ore, and mine life would be 10 years. As of November 2009, indicated resources at Crypto totaled 283 metric tons (t) of indium. The company has owned the property since 2005 (Lithic Resources Ltd., 2010).

Indium metal was not produced as a byproduct in the United States at any zinc or lead refineries. Production of indium consisted of upgrading imported indium metal and powder. Lower grade (99.97%) and standard-grade (99.99%) imported indium was refined to purities of up to 99.99999%. Indium metal was sold in various forms (foil, ingot, powder, ribbon, wire, and others). Indium Corp. of America (ICA) (Utica, NY) and Umicore Indium Products (Providence, RI, a division of n.v. Umicore, s.a., Olen, Belgium) accounted for the majority of U.S. production of indium metal and products. In October, it was reported that ICA planned to purchase a facility in Utica, NY, to expand its production capabilities (Schier, 2010).

Recycling

A large portion of global secondary indium was produced from indium-tin oxide (ITO) recycling. Spent ITO target recycling was concentrated in China, Japan, and the Republic of Korea—the countries where ITO production and sputtering takes place.

Indium can also be recovered from copper-indium-gallium-diselenide (CIGS) solar cells to be used in the manufacture of new CIGS solar cells. Indium may be reclaimed directly from old liquid crystal display (LCD) panels. The panels are crushed to millimeter-sized particles and then soaked in an acid solution to dissolve the ITO from which the indium is recovered.

Indium recovery from tailings was thought to have been insignificant, as these wastes contain small percentages of the metal and can be difficult to process. However, improvements to the process technology have made indium recovery from tailings feasible when the price of indium is high.

Consumption

Indium Tin Oxide.—Production of ITO was the leading end use of indium, accounting for the majority of global indium consumption. ITO is used for electrically conductive purposes in a variety of flat-panel display devices—most commonly, LCDs. Most ITO production was concentrated in Japan. Significant quantities of ITO also were produced in China, the Republic of Korea, and Taiwan. Demand for ITO increased during the first half of 2010 from that of the second half of 2009 owing to a rise in LCD panel production. However, LCD panel inventories began to increase during the second half of 2010 owing to lower-than-expected LCD sales in the United States and global economic uncertainty. One LCD panel producer initiated a 30% production cut at one of its Japanese plants to control inventory. As a result of weakening LCD demand in the second half of 2010, LCD panel producers lowered prices, resulting in an aggressive price competition among flat-screen LCD TV producers. However, ITO producers were not able to significantly lower the price for ITO owing to higher indium prices in 2010.

Alloys and Solders.—Alloys and solders were the second leading end use of indium globally. Indium-containing solders have lower crack propagation and improved resistance to thermal fatigue when compared to tin-lead solders. They also inhibit the leaching of gold components in electronic apparatus. Low-melting-point indium alloys are used as fuses or plugs for sprinkler systems. In the optical industry, low-melting-point alloys are applied to lenses and act as a surface for machine tools to grip during the polishing process. Certain types of indium alloys can be used as bonding agents between nonmetallic materials, such as glass, glazed ceramics, and quartz. Indium has also been used in dental alloys and in white gold alloys.

Other.—Another important use of indium was for III-V semiconductor materials for light-emitting diodes (LEDs) and laser diodes. In indium-based semiconductors, indium antimonide, indium arsenide, or indium phosphide can be used as the substrate, and several indium-containing compounds can be used as the epitaxial layer (or substrate coating), such as indium gallium arsenide. Indium-based LEDs are used predominantly to optically transmit data and, to a lesser extent, in LED displays. Indium-based laser diodes are used in fiber-optic communications.

Other uses of indium included electrodeless lamps, mercury alloy replacements, and nuclear control rods. Alkaline batteries use indium to prevent buildup of hydrogen gas within sealed battery casings.

Prices

The 2010 average annual Platts Metals Week New York dealer price range for indium [99.99% minimum purity in minimum lots of 50 kilograms (kg)] was $535 to $569 per kilogram. Indium prices began the year ranging from $460 to $500 per kilogram and generally increased through May, reaching a high of $580 to $640 per kilogram. Subsequently, prices slowly declined through December, ending the year at $520 to $570 per kilogram.

According to Platts Metals Week, the ICA producer price for indium (99.97% purity, 1-kilogram bar in lots of 10,000 troy ounces) began the year at $500 per kilogram. In early February, the price was raised to $570 per kilogram and remained at that level for the rest of the year.

Foreign Trade

During 2010, U.S. imports for consumption of unwrought indium metal and indium powders totaled 117 t, a 12% increase from the 105 t imported in 2009. Leading suppliers in 2010 were China (23%), Canada (20%), and Japan (18%). Belgium, Hong Kong, Taiwan, and the United Kingdom were also significant suppliers. There was no exclusive domestic export classification code for unwrought indium and indium powders.

World Review

Australia.—North Queensland Metals Ltd. (Fortitude Valley, Queensland) owned the Baal Gammon copper, tin, silver, and indium project near Herberton. Estimated probable ore reserves at Baal Gammon reportedly were 3.1 million metric tons (Mt) of ore grading 29.6 grams per metric ton of indium. North Queensland Metals was acquired by Conquest Mining Ltd. (Bondi Junction, New South Wales) in the fourth quarter (North Queensland Metals Ltd., 2009, p. 18; 2010).

Belgium.—Indium metal (foil and ingots) was produced at Umicore's precious metals refinery at Hoboken, near Antwerp. A special metals plant at the refinery recovered indium from dusts and residues generated by the facility's lead refinery. Production capacity was 50 metric tons per year (t/yr) of indium. Umicore recently installed a new process at Hoboken, which allows the company to reclaim the copper, indium, gallium, and selenium from CIGS solar cells, which Umicore then uses to manufacture new CIGS solar cells (Metal-Pages, 2010c).

Bolivia.—Bolivia was a significant producer of indium-bearing concentrates, which were exported and processed elsewhere.

Canada.—Refined indium was produced at Teck Resources Ltd.'s (Vancouver) lead-zinc metallurgical complex at Trail, British Columbia. Indium production capacity at Trail was about 75 t/yr. Actual production would be determined by the availability of indium-bearing concentrates.

Xstrata plc's (Zug, Switzerland) Kidd Creek copper-zinc metallurgical operations at Timmins, Ontario, usually produced approximately 10 to 15 t/yr of refined indium. Xstrata began to ramp-down operations at the smelter in May and ceased operations in mid-June. Previously, the smelter's copper operations were temporarily idled in August 2009 owing to a lack of concentrate feed from third parties. Concentrates from the nearby Kidd Creek copper-zinc-silver mine were redirected to Xstrata's Horne smelter in Quebec, which does not have the capability to extract indium. ICA had a supply contract with Xstrata for the indium produced at Kidd Creek (American Metal Market, 2010).

Canada has several indium-containing deposits that were being explored or were under development. Adex Mining Inc. began a drilling program in October to upgrade the inferred resources at the tin-indium-zinc North Zone deposit on its Mount Pleasant Mine property in New Brunswick to National Instrument (NI) 43–101 compliant indicated resources. The drilling program was being conducted as part of the feasibility study of the deposit (Adex Mining Inc., 2010).

Alexco Resource Corp. (Vancouver) completed construction of the Bellekeno silver-lead-zinc mine and mill in September. The mine is in the Keno Hill Silver District in the Yukon Territory. By November, the mill was operating at design capacity and was producing silver-lead and zinc concentrates that possibly contained payable indium. The company entered into offtake agreements with Glencore International AG (Baar, Switzerland) that allowed for the payment of indium once commercial quantities of the metal had been demonstrated within the concentrates (Alexco Resource Corp., 2010).

Avalon Rare Metals Inc. continued to evaluate the possible development of its East Kemptville tin-indium project in Nova Scotia. The company undertook an exploration program in areas surrounding the former East Kemptville tin mine to assess the indium and tin resources of the deposit. Avalon planned to commence a work program to identify resources that would comply with NI 43–101 requirements once approval for the program was gained from the government of Nova Scotia (Metal-Pages, 2010a).

China.—China was the leading global producer of primary indium, with some secondary production as well. Chinese indium production in 2010 increased from that of 2009, although some small- and medium-sized producers were reported to have reduced or stopped production during the year owing to increased environmental controls (Metal-Pages, 2010b).

Zhuzhou Keneng New Material Co., Ltd. added an indium production line with a 5 t/yr capacity. The company was reported to have produced 46 t of indium in 2009 (Metal-Pages, 2010d).

The total 2010 indium export quota was 233 t, unchanged from that of 2009. Zhuzhou Smelter Group was given the largest quota of 45.1 t, followed by Nanjing Foreign Economic & Trade Development Co., Ltd. (30.1 t), Guangxi China Tin Group Co., Ltd. (25.5 t), Zhuzhou Keneng New Material (24.9 t), Huludao Nonferrous Metals Group Import and Export Co., Ltd. (14.9 t), and Nanjing Germanium Factory Co., Ltd. (14.4 t). In 2010, China exported 124 t of indium metal, powder and scrap, of which 73% went to Japan (Roskill's Letters From Japan, 2010b; 2011, p. 2).

France.—Nyrstar NV's Auby zinc smelter had an indium recovery plant that produced a concentrate grading 20% indium, which was sold to third parties for further processing.

Germany.—Indium was produced at PPM Pure Metals GmbH (Langelsheim) and Norddeutsche Affinerie AG (Hamburg). PPM recovered indium from indium-containing materials at its special metals production facility in Langelsheim. The company produced high-purity indium ingot, semifinished products, and indium compounds. Norddeutsche Affinerie AG also produced high-purity indium, which it consumed for the development of solar cells.

Japan.—Japan was a significant recycler of indium. Indium recycling-companies included Asahi Pretec Corp., Dowa Metals & Mining Co., Ltd., Nikko Metals, Mitsui Mining & Smelting, Sumitomo Metal Mining Co., Ltd., and Toho Zinc Co., Ltd. Dowa Metals & Mining operated an indium recycling facility in Akita Prefecture. Production capacity at the facility was 150 t/yr of secondary indium. Dowa also had the capacity to produce 70 t/yr of primary indium. Dowa's production was sold to consumers in Japan. Asahi Pretec had the capacity to produce 200 t/yr of secondary indium at its ITO target recycling plant in Fukuoka.

Japan also is a leading consumer of indium. After declining each year since 2006, indium consumption was thought to have increased in 2010 from that of 2009. Most of the increase was attributed to rises in ITO production, which accounts for about 90% of Japan's indium consumption. Major Japanese indium consumers included ITO producers Mitsui Mining & Smelting, Nippon Mining & Metals, Sumitomo Metal Mining, Tosoh Corp., and Ulvac Technologies, Inc. Nippon Mining & Metals operated the world's leading ITO production plant—the 50-metric-ton-per-month (t/mo) Isohara plant near Tokyo. Mitsui Mining & Smelting operated the second-ranked ITO manufacturing plant, the Omuta plant in southern Japan, which had the capacity to produce about 20 to 30 t/mo of ITO (Platts Metals Week, 2008; Ryan's Notes, 2008; Watanabe, 2008).

Japanese shipments (including exports) of the semiconductor alloy, indium phosphide, increased by 15% in the second half of fiscal year 2009 (October 2009–March 2010) from that of the same period in the prior fiscal year. The increase in shipments was attributed to an overall recovery in demand for fiber optics (Roskill's Letters From Japan, 2010a).

Korea, Republic of.—Korea Zinc Co., Ltd. produced primary and secondary indium at its Onsan zinc refinery. Production capacity at the plant was thought to be 200 t/yr of indium, of which 100 t/yr was primary and 100 t/yr was secondary. Primary feedstock was sourced from zinc concentrates originating from Bolivia, and secondary feedstock was sourced from Japanese ITO producers. Korea Zinc produced 120 t of indium in 2010 (Roskill's Letters From Japan, 2011, p. 1).

Peru.—Refined indium was produced at Votorantim Metais' Cajamarquilla zinc refinery. Doe Run Peru's La Oroya metallurgical complex, which has the capacity to produce a small amount of indium, has been closed since June 2009.

Russia.—Chelyabinsk Zinc Plant OJSC and Ural Mining and Metals Co. (UMMC) produced refined indium. Refined indium produced in Russia was exported.

Outlook

Demand for indium will continue to follow demand for ITO and, more broadly, LCDs. Shipments of mobile devices continue to increase, with substantial increases forecast for media tablets and smart phones. The market share of LCD televisions is increasing, while that of plasma display panels is remaining level, and cathode ray tube televisions, decreasing. In 2011, shipments of flat-panel display televisions (FPD TVs) were expected to increase 6% from those of 2010 to 206 million units followed by a 9% increase in 2012. Globally, growth in demand for FPD TVs will be the strongest in developing areas—specifically, Africa, Asia Pacific, China, Eastern Europe, Latin America, and the Middle East—and demand in developed regions will decline slightly (DisplaySearch, 2011).

On the supply side, China was expected to continue to be the main global supplier of primary indium. Outside of China, Japan and the Republic of Korea have increased their recycling capabilities; however, there are no known plans to build additional primary refineries. The closure of Kidd Creek and La Oroya has removed nearly 20 t/yr of primary capacity. Several exploration projects at deposits containing recoverable amounts of indium are advancing, but it remains uncertain when many of these projects will come onstream.

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TABLE 1

U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT INDIUM METAL, BY COUNTRY[1]

	2009		2010	
Country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Belgium	8,790	$2,860	12,300	$6,040
Canada	44,600	13,400	23,500	12,300
China	19,000	7,040	27,400	13,600
Germany	57	19	344	164
Hong Kong	5,910	2,050	6,540	3,350
Japan	12,000	3,690	21,300	10,700
Kazakhstan	--	--	164	83
Korea, Republic of	3,320	973	450	181
Laos	--	--	652	46
Malaysia	322	69	921	334
Peru	2,570	737	--	--
Russia	--	--	3,390	1,870
Switzerland	594	26	209	123
Taiwan	1,600	563	6,760	3,490
Thailand	--	--	697	68
United Kingdom	6,500	3,780	12,900	6,350
Total	105,000	35,200	117,000	58,700

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 2

INDIUM: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Belgium	30	30	30	30	30
Brazil	--	--	--	--	5
Canada	52 [r]	61 [r]	57 [r]	50 [r]	67
China	400	370	340	330 [r]	340
Germany[3]	10	10	10	10	10
Italy	5	5	5	5	5
Japan	55	60	65	67	70
Kazakhstan	(4)	(4)	(4)	(4)	(4)
Korea, Republic of	60	70	75	70	120
Netherlands	5	5	5	5	5
Peru	6	5	6	2 [r]	2
Russia	10	10	10	4	NA
Ukraine[5]	NA	NA	NA	NA	NA
United Kingdom	5	5	5	5	5
Total	638 [r]	631 [r]	613 [r]	583 [r]	659

[r] Revised. NA Not available. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 4, 2011.

[3] Production of indium reinstated, because both PPM Pure Metals GmbH (PPM) and Norddeutsche Affinerie AG (NA) reported that they were producing indium in 2007. NA is reportedly using its own indium in designing new solar cell technologies, but no estimates of indium production were actually available. This data represents only estimated production by PPM at the company's Langelsheim special metals plant.

[4] Less than ½ unit.

[5] Information is not adequate to estimate production.

IRON AND STEEL

By Michael D. Fenton

Domestic survey data and tables were prepared by Hoa P. Phamdang, statistical assistant, and world production tables were prepared by Glenn J. Wallace, international data coordinator.

The global recession of 2008–09 caused a retraction of global steel industries through 2009, followed by a weak and uneven recovery throughout 2010. U.S. capacity utilization for raw steel production, which had dipped to a low of 41% in April 2009, rose steadily to a high of 75% in June 2010, but declined slightly to 73% at yearend. U.S. apparent steel consumption, which had decreased to a low of 63 million metric tons (Mt) in 2009, after a high of 120 Mt in 2006 and 102 Mt in 2008, rebounded to 80 Mt in 2010. Apparent consumption in China, the world's largest producer and consumer of steel, was expected to increase by less than 7% in 2010 after a strong increase of 25% in 2009. The U.S. automotive sector led the steel-consuming markets during the weak economic recovery. Prices per metric ton for hot-roll sheet steel reached a high of $822 in early 2010 after a low of $382 in mid-2009, but then decreased to $559 by yearend 2010. Recent unprecedented rises of iron ore and metallurgical coal prices, along with the replacement of annual contracts by a 3-month spot price for iron ore, adversely affected steelmaking companies and their customers.

According to the World Steel Association (WSA) (2011a), China was the top steel producer in the world during 2010 (627 Mt), with its leading steelmaker, Baosteel Group Corp. (37 Mt), placing second behind the world's leading steelmaker ArcelorMittal (98.2 Mt). India became the world's fourth-leading steel producer (68.3 Mt), behind the United States (80.5 Mt), and ahead of the fifth-leading producer Russia (66.9 Mt). Japan ranked first in the world for total exports of steel, followed by the European Union (EU). China ranked first in the world for total imports of steel followed by the EU and then the Republic of Korea.

The American Iron and Steel Institute (AISI) reported U.S. production of iron and steel and shipments of steel mill products. These data can be regarded as representing 100% of the raw steel producers in the United States. World production of iron and steel was reported by the WSA and by foreign government agencies. Consistent with international usage and Federal Government policy, the U.S. Geological Survey reported all data on iron and steel in metric units unless otherwise noted.

Environmental Issues

The American Power Act (APA), a so-called "cap and trade" bill, introduced in the U.S. Senate, was very similar to a bill that was passed earlier in the U.S. House of Representatives (Power and Talley, 2010). Under a cap-and-trade system, the Federal Government would require companies to hold permits in order to emit greenhouse gases. Companies would be allowed to trade permits among themselves. AISI and the National Association of Manufacturers voiced concerns that the bill's provisions related to manufacturing and energy do not go far enough to ensure the continued competitiveness in the global marketplace (American Iron and Steel Institute, 2010). While the Senate deliberated, the U.S. Environmental Protection Agency (EPA) regulated greenhouse gas emissions under the Clean Air Act, issuing the Tailoring Rule on May 13, 2010. The AISI and Massey Energy Co., among others, took legal steps to oppose the EPA regulatory actions. A number of State regulators and other associations also opposed new Federal rules curbing industrial greenhouse-gas emissions (Hill, The, 2009).

The U.S. steel industry has reduced its energy consumption per ton of steel shipped by 30% since 1990 (American Iron and Steel Institute, 2010). During the same period, greenhouse gas emissions were reduced by 35%. The U.S. steel industry had the lowest average carbon dioxide emissions per ton of steel produced in the global steel industry (American Iron and Steel Institute, 2010). Also, the American steel sector is recognized as having the steepest decline in total air emissions among nine manufacturing sectors studied in the EPA's 2008 Sector Performance Report (U.S. Environmental Protection Agency, 2008. p. 5).

Production

Raw steel production in the United States was about 80.5 Mt in 2010, up about 36% from that in 2009 (table 1). The AISI estimated raw steel production capability to be 114 Mt, up slightly from that in 2009. Production represented 70.4% of estimated capacity, up from 52.4% in 2009.

Integrated steel producers smelted iron ores to make liquid iron in blast furnaces and used basic oxygen furnaces to refine the liquid iron with some steel scrap to produce raw liquid steel. The basic oxygen process was used to make 31.2 Mt of steel in the United States (American Iron and Steel Institute, 2011, p. 72). The use of this process increased to 38.7% of total steel production in 2010 from 38.2% in 2009. Blast furnace operations in the United States were operated by 5 companies at 15 locations in 2010 (Iron and Steel Technology, 2011a, p. 268).

Minimills and specialty mills are nonintegrated steel producers that use the electric arc furnace (EAF) to melt low-cost raw materials (usually scrap). They also employ continuous casting machines and hot-rolling mills that are often closely coupled to casting operations. Specialty mills include producers of alloy-electrical, stainless, and tool steel; high-temperature alloys; forged ingots; and other low-volume steel products. About 100 companies operated about 112 EAF facilities in the United States during 2010 (Iron and Steel Technology, 2011b, p. 126). These U.S. mills used the EAF steelmaking process to produce 49.3 Mt of steel, a 34% increase from that in 2009, and accounted for 61.3% of total steelmaking (American Iron and Steel Institute, 2011, p. 72–73).

Raw liquid steel is mostly cast into semifinished products in continuous casting machines. Only 2.6% of U.S. production was cast in ingot form in 2010, and subsequently rolled into semifinished forms, a slightly higher percentage than that of 2009. Continuous casting production was 78.4 Mt, or 97.4% of total steel production, 35.4% higher than in 2009 (American Iron and Steel Institute, 2011, p. 73).

Consumption

Steel mill products are produced at steel mills either by forging or rolling into forms normally delivered for fabrication or use. Some companies purchase semifinished steel mill products from other steel companies and use them to produce finished steel products. The accumulated shipments of all companies less the shipments to other reporting companies are identified as net shipments to avoid double counting.

U.S. apparent steel consumption, an indicator of economic growth, increased to 80 Mt in 2010 from 63 Mt in 2009. Net shipments of steel mill products by U.S. companies increased by 34% to 75.7 Mt compared with those of 2009 (American Iron and Steel Institute, 2011, p. 25). Compared with those in 2009, shipments of construction and contractors' products, the leading single end-use market for steel, increased by 21% in 2010; automotive product shipments increased by 32%; shipments of agricultural and industrial machinery, equipment, and tools increased by 43%; steel service center shipments increased by 48%; lumbering, mining, oil and gas, and quarrying industries shipments increased by 126%; and shipments of appliances and containers, packaging, and shipping material decreased by 15% (American Iron and Steel Institute, 2011, p. 29).

Prices

The U.S. Department of Labor, Bureau of Labor Statistics (2011), producer price index for steel mill products increased by 16% to 191.7 in 2010 from 165.2 in 2009 (1982 base=100) (table 1). The average price of hot-rolled steel sheet increased steadily from $541 per short ton in January to a high of $684 per short ton in April, before decreasing to a low of $539 in November and then increasing to $670 per short ton in December (Purchasing Magazine, 2010).

Foreign Trade

Export shipments of steel mill products by AISI reporting companies increased to 11.0 Mt from 8.42 Mt in 2009 (table 1). Canada received the largest amount of U.S. exported steel, 6.1 Mt, 43% more than that in 2009 (table 4). Mexico was again the second leading importer, receiving 2.4 Mt, 30% more than that in 2009. Domestic imports of steel mill products increased by 48% to 21.7 Mt from 14.7 Mt in 2009. Canada, China, the EU, Japan, the Republic of Korea, and Mexico, were major sources of steel mill product imports in 2010 (table 4).

Imports of semifinished steel (table 6) by steel companies are taken into consideration in evaluating apparent consumption (supply) of steel mill products in the United States and the share of the market represented by imported steel. To avoid double counting the imported semifinished steel and the products produced from it, the amount of semifinished steel consumed by companies that also produced raw steel is subtracted from domestic consumption. Between 1993 and 2006, semifinished steel imports ranged between 2.5 million metric tons per year (Mt/yr) and 8.5 Mt/yr. Prior to 1993, the amount was less than 0.2 Mt/yr. Taking the imported semifinished steel into consideration, the share of the U.S. steel market represented by imported steel was an estimated 26% in 2010 compared with 25% in 2009.

U.S. imports recovered from 2009 lows and the steel industry, among others, continued to seek protection from low-priced Chinese competition that was blamed for lost sales and jobs. U.S. companies and the U.S. Government filed import injury cases against China with the World Trade Organization and the U.S. International Trade Commission (USITC), accusing Chinese competitors of receiving government subsidies, thus allowing the sale of products in the United States at artificial and unfairly low prices. Also, Chinese consumption has not kept up with industrial overcapacity, thus resulting in excessive exporting to the United States of low-priced products. A 35% tariff on Chinese-made tires in 2009 was followed in late 2009 by several USITC rulings in favor of domestic steelmakers, including duties of 10% to 16% against Chinese exporters of steel pipe used mostly for the oil and gas industries, duties of 2% to 438% applied to imports of steel wire decking, and duties of 45% to 289% on Chinese steel imports (Palmer, 2010a, b, c).

"Fabricated steel products" reported in tables 4, 5, and 6 are those products produced from steel mill products but do not include products that incorporate steel products with other materials. Examples of fabricated steel products are structural steel and steel fasteners. "Other iron and steel products" refers to products that are not produced from steel mill products. Examples of other iron and steel products include iron or steel castings and direct reduced iron (DRI).

World Review

World production of pig iron totaled about 1.03 billion metric tons (Gt), about 12% more than that in 2009 (table 9). Pig iron production of the EU was about 95 Mt, 24% more than that in 2009. Germany was the leading producer in the EU, producing about 29 Mt, 42% more than that in 2009. China continued to be the leading producer of pig iron in the world, producing more than 590 Mt, 7% more than that of 2009, followed by Japan (82 Mt), Russia (49 Mt), India (39 Mt), the Republic of Korea (31 Mt), Germany (29 Mt), Ukraine (28 Mt), the United States (27 Mt), and Brazil (25 Mt). Russia and Ukraine were the only major pig iron producers in the Commonwealth of Independent States (CIS). In North America, the only major producer of pig iron was the United States, where in 2010 production increased by 41% from that in 2009. In South America, the only major pig iron producer was Brazil.

World capacity for DRI production in 2010 was estimated to be about 82 Mt/yr (Midrex Technologies, Inc., 2011). DRI production worldwide reached a record of 68.7 Mt in 2010, 4.6% more than that in 2009 (table 9). The leading producer of DRI was India, followed by, in descending order of tonnage, Iran, Venezuela, and Mexico. In 2010, additional DRI capacity of almost 20 Mt/yr was under construction in China, Egypt, India, Iran, Oman, Pakistan, the United Arab Emirates, and

Venezuela. The leading technology was the Midrex process, followed by the HYL I and the HYL III processes.

World production of raw steel was 1.41 Gt, 15% more than the revised production in 2009 (table 10). Steel production increased during 2010 in North America (33%), the EU and South America (20% each), and the CIS (12%). Positive growth also took place in India (18%) and China (10%). China produced 44% of world total crude steel in 2010. As in previous years, production varied widely among major regions of the world. Asian countries produced about 56% of the world's steel; the EU, 14%; North America, 8%; and the CIS, 8%.

During 2010, China was again the world's leading steel producer, almost 627 Mt, a gain of 10% compared with that of 2009. In descending order of production, the leading producers behind China were Japan, the United States, India, Russia, the Republic of Korea, and Germany. These six countries accounted for 73% of world production. The combined steel production of the seven steel-producing countries in the CIS was about 108 Mt, an increase of 12% from that in 2009. Russia and Ukraine remained the leading producers in the CIS. U.S. steel production during 2010 was greater than 80 Mt, an increase of 36% from that in 2009.

SteelOrbis (2011) reported that world steel capacity utilization rate at yearend 2010 was about 74%, after a low of about 57% in December 2008 and a high of 83% in April 2010. China, the leading steel-consuming and steel-producing country in the world, had a capacity utilization rate of 89% in 2010, compared with 83% in 2008 (Ernst & Young, 2010).

Outlook

The expansion or contraction of gross domestic product (GDP), the broadest measure of a nation's economic activity, may be considered a predictor of the health of the steelmaking and steel manufacturing industries, worldwide and domestically. The World Bank's forecast of global GDP growth for 2010, 2011, 2012, and 2013 was 3.8%, 3.2%, 3.6%, and 3.6%, respectively (World Bank, The, 2011). The International Monetary Fund's forecast of world GDP growth for 2010, 2011, and 2012 was 5.1%, 4.3%, and 4.5%, respectively (International Monetary Fund, 2011). The U.S. Federal Reserve's forecast for the U.S. 2011 GDP growth rate was between 3.4% and 3.9%, and between 3.5% and 4.4% for 2012 (Board of Governors of the Federal Reserve System, 2011). The 2010 GDP growth for China was 10.3% and was projected to be 9.3% and 8.7% in 2011 and 2012, respectively, and that of India was 8.8%, 8.0%, and 8.4% for those years, respectively (World Bank, The, 2011).

MEPS (International) Ltd. forecast total world steel production in 2011 to be 1.568 Gt, up 11% from that in 2010, and 1.625 Gt for 2014 [MEPS (International) Ltd., 2011]. MEPS also forecast increasing steel production in 2011 in South America, the Middle East, China, the CIS, and the EU of 17%, 11%, 8%, 5%, and 4%, respectively. For China, MEPS forecast a 19% increase in steel production by 2014 compared with that in 2010.

The progression of the U.S. financial downturn into a global economic downturn brought about a global decline of steel demand in late 2008 and through 2010. Improvement in 2011 will depend on the effects of Government stimulation packages, stabilization of financial systems, and a return of consumer confidence.

World apparent steel consumption (ASC) was expected to increase by 6% to 1.359 Gt during 2011, after increasing by 13% in 2010, and then increase by 6% in 2012, to reach a historic high of 1.44 Gt (World Steel Association, 2011b). China's ASC was expected to increase by 5% to 605 Mt in 2011, and then by 5% in 2012 to 635 Mt. ASC in India was expected to increase by 13% in 2011 to about 69 Mt and 14% in 2012. The U.S. ASC was expected to increase by 13% to 90 Mt in 2011. The EU's ASC was expected to increase by 5% to 152 Mt in 2011 and increase by 4% in 2012. In Japan, the 2011 ASC was expected to decrease by 1.2% to 63 Mt, and remain at this level during 2012. The ASC of the CIS was expected to increase by nearly 8% to 52 Mt in 2011 and then by 9% in 2012.

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TABLE 1
SALIENT IRON AND STEEL STATISTICS[1]

(Thousand metric tons unless otherwise noted)

	2006	2007	2008	2009	2010
United States:					
Pig iron:					
Production[2]	37,900	36,300	33,700	19,000	26,800
Exports[3]	813	71	51	10 [r]	2,220
Imports for consumption[3]	6,730	5,220	4,980	2,420	3,780
Direct-reduced iron:					
Production[4]	240	250	260	--	--
Exports[3]	(5)	(5)	(5)	(5)	(5)
Imports for consumption[3]	2,610	2,330	2,340	1,020	1,640
Raw steel production:[6]					
Carbon steel	89,500	89,800	84,100	55,200 [r]	73,600
Stainless steel	2,460	2,170	1,930	1,620	2,200
All other alloy steel	6,190	6,140	5,810	2,620	4,680
Total	98,200	98,100	91,900 [r]	59,400	80,500
Capability utilization, percent	87.5	87.0	81.4	52.4 [r]	70.4
Steel mill products:					
Net shipments[2]	99,300	96,500	89,400	56,400	75,700
Exports[2]	8,830	10,100	12,200	8,420	11,000
Imports[2]	41,100	30,200	29,000	14,700	21,700
Producer price index (1982=100.0)[7]	174.1	182.9	220.6	165.2	191.7
World production:[8]					
Pig iron	881,000	956,000 [r]	931,000	920,000 [r]	1,030,000
Direct-reduced iron[4]	58,700 [r]	64,100 [r]	66,700 [r]	65,700 [r]	68,700
Raw steel	1,250,000	1,350,000	1,330,000	1,240,000	1,420,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits, except producers price index; may not add to totals shown.

[2] Data are from the American Iron and Steel Institute (AISI).

[3] Data are from the U.S. Census Bureau.

[4] Data are from Midrex Technologies, Inc., government, and companies.

[5] Less than ½ unit.

[6] Raw steel is defined by AISI as steel in the first solid state after melting, suitable for rolling.

[7] Data are from the U.S. Department of Labor, Bureau of Labor Statistics.

[8] Data are from the U.S. Geological Survey and the World Steel Association.

TABLE 2
MATERIALS CONSUMED IN BLAST FURNACES AND PIG IRON PRODUCED[1]

(Thousand metric tons)

Material	2009	2010
Iron oxides:[2]		
Ores	--	--
Pellets	26,200	36,000
Sinter[3]	3,720	5,090
Total	29,900	41,100
Scrap[4]	1,460	1,090
Coke[2]	7,650	8,430
Pig iron, produced	19,000	26,800

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] American Iron and Steel Institute.

[3] Includes sintered ore and pellet fines, dust, mill scale, and other revert iron-bearing materials; also some nodules.

[4] Mainly briquetted turnings and borings, shredded scrap, etc.; scrap produced at blast furnaces and remelt not included.

TABLE 3
DISTRIBUTION OF SHIPMENTS OF STEEL MILL PRODUCTS, BY STEEL TYPE, PRODUCT, AND MARKET[1]

	Quantity (thousand metric tons)		Percentage	
	2009	2010	2009	2010
Shipments by steel type:				
Carbon steel	53,100 r	71,000	94.08 r	93.76
Alloy steel	2,140	3,210	3.79	4.25
Stainless steel	1,200	1,510	2.13	1.99
Total	56,400	75,700	100.00	100.00
Steel mill products:				
Ingots, blooms, billets and slabs	801	927	1.42	1.22
Wire rods	1,490	1,710	2.65 r	2.25
Structural shapes, heavy	3,380	3,880	6.00 r	5.13
Steel piling	382	819	0.68	1.08
Plates, cut lengths	4,100	5,660	7.28 r	7.47
Plates, in coils	2,120 r	3,030	3.75 r	4.01
Rails	712	713	1.26	0.94
Railroad accessories	190	190	0.34	0.25
Bars, hot-rolled	3,100	4,080	5.50	5.39
Bars, light-shaped	1,090	1,760	1.93	2.33
Bars, reinforcing	4,620 r	5,740	8.18 r	7.58
Bars, cold finished	827	1,180	1.47	1.55
Tool steel	7	8	0.01	0.01
Pipe and tubing, standard pipe	535	626	0.95	0.83
Pipe and tubing, oil country goods	945	1,960	1.68	2.59
Pipe and tubing, line pipe	169	302	0.30	0.40
Pipe and tubing, mechanical tubing	387	521	0.69	0.69
Pipe and tubing, pressure tubing	22	39	0.04	0.05
Pipe and tubing, stainless	9	10	0.02	0.01
Pipe and tubing, structural	62	61	0.11	0.08
Wire	288	272	0.51	0.36
Tin mill products, blackplate	62	100	0.11	0.13
Tin mill products, tinplate	1,580	1,840	2.81 r	2.44
Tin mill products, tin-free steel	453	474	0.80	0.63
Tin mill products, tin coated sheets	66	84	0.12	0.11
Sheets, hot-rolled	12,200 r	16,600	21.55 r	21.88
Sheets, cold-rolled	6,780	9,070	12.02	11.98
Sheets and strip, hot dip galvanized	7,350	10,700	13.04 r	14.10
Sheets and strip, electrogalvanized	1,020	1,510	1.81	2.00
Sheets and strip, other metallic coated	654	965	1.16	1.27
Sheets and strip, electrical	326	306	0.58	0.40
Strip, hot rolled	28	37	0.05	0.05
Strip, cold rolled	693	584	1.23	0.77
Total	56,400	75,700	100.00	100.00
Shipments by markets:				
Service centers and distributors	13,800	20,400	24.43 r	26.96
Construction	13,500	16,300	23.87 r	21.53
Automotive	7,300	9,620	12.94	12.71
Machinery	542 r	795	0.96 r	1.05
Containers	2,040	2,390	3.61 r	3.15
All others	19,300 r	26,200	34.20 r	34.60
Total	56,400	75,700	100.00	100.00

r Revised.

[1] Data are rounded to no more than three significant digits, except percentages; may not add to totals shown.

Source: American Iron and Steel Institute.

TABLE 4
U.S. IMPORTS AND EXPORTS OF STEEL MILL PRODUCTS, BY COUNTRY[1]

(Thousand metric tons)

Country	2009		2010	
	Imports	Exports	Imports	Exports
Argentina	75	74	128	15
Australia	258	15	--	28
Brazil	654	135	903	143
Canada	3,880	4,270	6,030	6,100
China	1,330	194	781	116
European Union[2]	1,760	278	2,570	342
Germany	450	43	1,090	73
Japan	1,110	13	1,350	16
Korea, Republic of	1,200	55	1,850	72
Mexico	1,590	1,840	2,560	2,390
Russia	492	--	1,250	--
South Africa	30	9	117	2
Sweden	150	61	253	14
Taiwan	336	92	486	88
Turkey	446	--	528	--
Ukraine	46	--	118	--
Venezuela	69	66	--	62
Other	840 r	1,280	1,710	1,540
Total	14,700	8,420	21,700	11,000

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes Germany and Sweden.

Source: American Iron and Steel Institute.

TABLE 5

U.S. EXPORTS OF IRON AND STEEL PRODUCTS[1]

(Thousand metric tons)

	2009	2010
Steel mill products:		
Ingots, blooms, billets, slabs	589	609
Wire rods	144	170
Structural shapes, heavy	516	760
Steel piling	30	31
Plates, cut lengths	814	1,070
Plates, in coils	704	979
Rails, standard	88	84
Rails, other	29	23
Railroad accessories	14	27
Bars, hot-rolled	390	563
Bars, light-shaped	92	235
Bars, concrete reinforcing	390	520
Bars, cold-finished	109	147
Tool steel	13	29
Pipe and tubing, standard pipe	74	95
Pipe and tubing, oil country goods	273	366
Pipe and tubing, line pipe	198	186
Pipe and tubing, mechanical tubing	37	38
Pipe and tubing, stainless	29	33
Pipe and tubing, nonclassified	309	370
Pipe and tubing, structural	181	221
Pipe for piling	25	20
Wire	143	193
Tin mill products, blackplate	3	3
Tin mill products, tinplate	220	208
Tin mill products, tin-free steel	13	21
Sheets, hot-rolled	717	876
Sheets, cold-rolled	582	832
Sheets and strip, hot-dip galvanized	726	960
Sheets and strip, electrogalvanized	290	393
Sheets and strip, other metallic coated	174	240
Sheets and strip, electrical	205	213
Strip, hot-rolled	157	194
Strip, cold-rolled	144	298
Total	8,420	11,000
Fabricated steel products:		
Structural shapes, fabricated	319	384
Rails, used	34	16
Railroad products	41	64
Wire rope	18	19
Wire, stranded products	31	30
Wire, other products	85	122
Springs	100	142
Nails and staples	27	30
Fasteners	678	911
Chains and parts	28	37
Grinding balls	83	114
Pipe and tube fittings	27	38
Other[2]	84	104
Total	1,560	2,010
Grand total	9,980 r	13,000

See footnotes at end of table.

TABLE 5—Continued
U.S. EXPORTS OF IRON AND STEEL PRODUCTS[1]

(Thousand metric tons)

	2009	2010
Cast iron and steel products:		
Cast steel pipe fittings	27	38
Cast iron pipe and fittings	101	115
Cast steel rolls	2	1
Cast grinding balls	27	34
Granules, shot and grit	26	31
Other castings	55	68
Total	238	287

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes shapes cold formed, sashes and frames, fence and sign post, architectural and ornamental work, and conduit.

Source: American Iron and Steel Institute.

TABLE 6

U.S. IMPORTS OF MAJOR IRON AND STEEL PRODUCTS[1]

(Thousand metric tons)

	2009	2010
Steel mill products:		
Ingots, blooms, billets, and slabs	1,850	4,600
Wire rods	692	1,200
Structural shapes-heavy	337	474
Steel piling	49	77
Plates, cut lengths	481	680
Plates, in coils	645	928
Rails and railroad accessories	259	260
Bars, hot-rolled	612	952
Bars, light-shaped	78	99
Bars, reinforcing	380	469
Bars, cold-finished	169	243
Tool steel	52	122
Pipe and tubing, standard pipe	538	705
Pipe and tubing, oil country goods	1,450	2,160
Pipe and tubing, line pipe	1,450	1,350
Pipe and tubing, mechanical tubing	302	386
Pipe and tubing, pressure tubing	57	78
Pipe and tubing, stainless	81	100
Pipe and tubing, nonclassified	13	22
Pipe and tubing, structural	231	282
Pipe for piling	14	14
Wire	441	573
Tin mill products-blackplate	38	31
Tin mill products-tinplate	293	459
Tin mill products-tin-free steel	78	134
Sheets, hot-rolled	1,580	2,180
Sheets, cold-rolled	1,030	1,110
Sheets and strip, hot-dip galvanized	937	1,290
Sheets and strip, electrogalvanized	85	91
Sheets and strip, other metallic coated	270	375
Sheets and strip, electrical	60	86
Strip, hot-rolled	41	40
Strip, cold-rolled	112	144
Total	14,700	21,700
Fabricated steel products:		
Structural shapes, fabricated	965	772
Rails, used	57	53
Railroad products	97	125
Wire rope	113	140
Wire-stranded products	158	202
Springs	214	280
Nails and staples	388	492
Fasteners	779	957
Chains and parts	98	116
Pipe and tube fittings	203	265
Other	456	709
Total	3,530	4,110
Grand total	18,200	25,800

See footnotes at end of table.

TABLE 6—Continued
U.S. IMPORTS OF MAJOR IRON AND STEEL PRODUCTS[1]

(Thousand metric tons)

	2009	2010
Cast iron and steel products:		
Cast steel pipe fittings	203	265
Cast iron pipe and fittings	35	25
Other products	226	315
Total	464	605

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: American Iron and Steel Institute.

TABLE 7
U.S. IMPORTS OF STAINLESS STEEL[1]

(Metric tons)

Product	2009	2010
Semifinished	70,200	101,000
Plate	46,800	88,600
Sheet and strip	200,000 r	353,000
Bars and shapes	76,200 r	110,000
Wire and wire rods	40,700	60,300
Pipe and tube	81,300	99,700
Total	515,000 r	813,000

r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: American Iron and Steel Institute.

TABLE 8
COAL AND COKE AT COKE PLANTS[1, 2]

(Thousand metric tons)

	2009	2010
Coal, consumption	13,900	19,100
Coke:[3]		
Production	10,100	13,600
Exports	1,190	1,330
Imports	315	1,100
Consumption, apparent	9,360	13,500

[1] Data are rounded to no more than three significant digits.

[2] Includes furnace and merchant coke plants.

[3] Coke production and consumption do not include breeze.

Source: Energy Information Administration, Quarterly Coal Report, DOE/EIA–0121(2010/04Q).

TABLE 9

PIG IRON AND DIRECT-REDUCED IRON: WORLD PRODUCTION, BY COUNTRY[1, 2, 3, 4]

(Thousand metric tons)

Country[5]	2006	2007	2008	2009	2010
Algeria	1,093	1,193	690[e]	493[r]	600
Argentina:					
Pig iron	2,481	2,593	1,847	807	1,570
Direct-reduced iron	1,947	1,810	2,581	2,042	2,000[e]
Australia	6,276	6,351	6,409	4,370[r]	6,000[e]
Austria	5,547	5,808	5,815[r]	4,353[r]	5,621
Belgium	7,516	6,576	7,125	3,087	4,725
Bosnia and Herzegovina	60[e]	60[e]	243	482[r]	621
Brazil:					
Pig iron	32,452	35,571	34,871[r]	25,135[r]	25,200[p]
Direct-reduced iron[e]	376	362	302	305	305
Bulgaria	1,147	1,069	441	--	--
Burma:[e]					
Pig iron	2	2	2	2	2
Direct-reduced iron	40	40	40	40	40
Canada:					
Pig iron[e]	8,305[6]	8,577[6]	9,000	5,000	6,000
Direct-reduced iron	446	910	690[e]	300[e]	800
Chile	1,115	1,147	1,150[r]	923[r]	605[e]
China[7]	412,450	476,520	470,670	552,830[r]	590,220
Colombia	360	341	300	342[r]	370
Czech Republic	5,191	5,289	4,737	3,483	3,987
Egypt:					
Pig iron	1,100	1,000	1,000	3,900[r]	3,600
Direct-reduced iron[e]	3,100	2,786[6]	2,600[r]	3,100[r]	3,000
Finland	3,056[r]	2,914	2,943[r]	2,042[r]	2,100
France	13,013	12,426	11,372	8,105	10,137
Germany:					
Pig iron	30,360	31,149	29,111	20,104[r]	28,560
Direct-reduced iron[e]	580	590	520	380	450
Hungary	1,335	1,394	1,289	1,050	1,326
India:					
Pig iron	28,300	28,800	29,000[e]	34,000[r]	38,685
Direct-reduced iron	14,740	18,100	20,200[e]	21,000	20,650
Indonesia, direct-reduced iron[e]	1,290[6]	1,420	1,290	1,300	1,350
Iran:[e]					
Pig iron	2,041[6]	2,572[r, 6]	2,200	2,300[r]	2,300
Direct-reduced iron	6,850	7,440	7,500[r]	8,000	9,000
Italy	11,497	11,110	10,373	5,719	8,549
Japan	84,270	86,771	86,171	66,943[r]	82,283
Kazakhstan	3,369[r]	3,795[r]	3,106[r]	2,997[r]	2,984
Korea, North[e]	900	900	900	900	900
Korea, Republic of	27,559	29,437	31,043	27,405[r]	31,228
Libya, direct-reduced iron	1,633	1,660	1,569	1,097	1,300
Malaysia, direct-reduced iron	1,277	1,840	1,957	2,388[r]	2,400[e]
Mexico:					
Pig iron	3,800	4,077	4,670	3,929	4,720
Direct-reduced iron	6,167	6,265	5,940	4,203	5,455
Morocco[e]	15	15	15	15	15

See footnotes at end of table.

TABLE 9—Continued

PIG IRON AND DIRECT-REDUCED IRON: WORLD PRODUCTION, BY COUNTRY[1, 2, 3, 4]

(Thousand metric tons)

Country[5]	2006	2007	2008	2009	2010
Netherlands[8]	5,417	6,412	6,130	4,655	5,799
New Zealand[e]	664	679	622	608	667
Nigeria	150	200	--	-- [e]	--
Norway[e]	100	100	100	100	100
Pakistan[e]	1,200	1,000	1,000	1,000	1,000
Paraguay	136	148	145	146	146 [e]
Peru:[e]					
Pig iron	306	351 [6]	395 [6]	400	400
Direct-reduced iron	84	90	72	75	75
Poland	5,333	5,804	4,934	2,984 [r]	3,625
Portugal[e]	100	100	100	100	100
Qatar, direct-reduced iron	880	1,200	1,700 [e]	2,100	2,200
Romania	3,946	3,923	2,945	1,575 [r]	1,880
Russia:					
Pig iron	51,683	51,523	48,300	43,930	48,600 [e]
Direct-reduced iron	3,280 [r]	3,410 [r]	4,560 [r]	4,670 [r]	4,700 [e]
Saudi Arabia, direct-reduced iron	3,580	4,340	4,970	5,000 [e]	5,000 [e]
Serbia	1,529	1,485	1,582	1,006	1,265
Slovakia	4,145	4,012	3,529	3,019	3,649
South Africa:					
Pig iron	6,159	5,358	5,350	4,376	8,220
Direct-reduced iron	1,754	1,736	1,190	1,340 [r]	1,845
Spain	3,432	3,974	3,995	4,000 [e]	4,000 [e]
Sweden	3,577	3,815	3,800 [e]	3,700	3,800 [e]
Taiwan	10,500	10,550	9,750	7,939	9,358
Trinidad and Tobago, direct-reduced iron	2,072	2,065	1,600	1,182	1,000 [e]
Turkey[e]	5,952 [6]	6,234 [6]	6,600	7,000	8,000
Ukraine	32,926	35,647	30,982	25,676	28,375
United Kingdom	10,736	10,960	10,137	7,674	7,235
United States:					
Pig iron	37,900	36,300	33,700	19,000	26,800
Direct-reduced iron	240	250	260	--	--
Venezuela, direct-reduced iron	8,400	7,782	7,140	7,150	7,150 [e]
Zimbabwe[e]	38	--	--	--	--
Grand total	939,000	1,020,000	997,000	985,000 [r]	1,090,000
Of which:					
Pig iron[9]	881,000	956,000 [r]	931,000	920,000 [r]	1,030,000
Direct-reduced iron[10]	58,700 [r]	64,100 [r]	66,700 [r]	65,700 [r]	68,700

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Production is pig iron unless otherwise specified.

[3] Direct-reduced iron is obtained from ore by reduction of oxides to metal without melting.

[4] Table excludes ferroalloy production except where otherwise noted. Table includes data available through September 8, 2011.

[5] In addition to the countries listed, Vietnam has facilities to produce pig iron and may have produced limited quantities during 2006–10, but output is not reported and available information is inadequate to make reliable estimates of output levels.

[6] Reported figure.

[7] Figures reported by State Statistical Bureau that the Government of China considers to be official statistical data.

[8] Includes blast furnace ferroalloys.

[9] Includes unspecified pig iron and direct-reduced iron.

[10] Listed separately.

TABLE 10
RAW STEEL: WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Thousand metric tons)

Country[4]	2006	2007	2008	2009	2010
Albania	206	263	380	440	440 [e]
Algeria	1,158	1,278	646	458	700
Argentina	5,533	5,387	5,441	4,014	5,138
Australia	7,937	8,047	7,724	6,135	7,140
Austria	7,129	7,578	7,594	5,662	7,206
Azerbaijan	54	273	300 [e]	79 [r]	129
Bangladesh[e, 5]	10	-- [6]	--	--	--
Belarus	2,100	2,214	2,660	2,449 [r]	2,672
Belgium	11,238	10,692	10,676	5,636	8,088
Bosnia and Herzegovina, ingot production	490	533	608	519	593
Brazil[7]	30,901	33,782	33,726 [r]	26,506 [r]	33,200 [e]
Bulgaria	2,124	1,909	1,330	726	740
Burma[e]	25	25	25	25	25
Canada	15,493	15,569	15,130	9,000 [e]	12,000 [e]
Chile[7]	1,627	1,679	1,523	1,308 [r]	992 [e]
China[8]	419,150	489,290	500,490	572,180 [r]	626,650
Colombia	1,221	1,245	1,053	1,079	1,209
Croatia	81	76	122 [r]	52	110 [e]
Cuba	257	262	274	274 [e]	265 [e]
Czech Republic	6,862	7,059	6,387	4,594	5,180
Ecuador	85	87	128 [r]	259 [r]	368
Egypt	6,045	6,224	6,198	5,508	6,700
El Salvador	72	73	71 [r]	56 [r]	51
Ethiopia, all from scrap[e]	60	110	150	150	150
Finland	5,052	4,431	4,418	3,078	3,100
France	19,857	19,252	17,874	12,836	15,416
Germany	47,224	48,550	45,833	32,670 [r]	43,830
Ghana, all from scrap[e]	25	25	--	--	--
Greece	2,416	2,554	2,400 [e]	2,082	2,100
Guatemala	292	349	250	224	272
Hong Kong[e]	550	550	550	550	500
Hungary	2,144	2,317	2,160	1,425 [r]	1,678
India	49,450 [r]	53,468 [r]	57,791 [r]	63,527 [r]	68,321
Indonesia	3,759	4,160	3,915	3,500 [e]	3,700
Iran[e]	9,789 [6]	10,051 [6]	9,960	10,000	12,000
Israel[e]	480	480	480	380 [r]	430 [e]
Italy	31,550	31,990	30,477	19,737	25,751
Japan	116,266	120,203	118,739	87,500	109,600
Jordan[e]	150	150	150	150	150
Kazakhstan	4,245	4,784	4,244	4,147	4,256
Korea, North[e]	1,180	1,230	1,279 [6]	1,300	1,300
Korea, Republic of	48,455	51,517	53,322	48,752 [r]	49,000 [e]
Latvia[e]	550	550	550	550	550
Libya	1,151	1,151	1,137	914	1,100
Luxembourg	2,802	2,858	2,582	2,215	2,563
Macedonia	360	372	252	276 [r]	291
Malaysia	5,834	6,895	6,423	5,787 [r]	6,100 [e]
Mauritania	1	1	2	2 [e]	2 [e]
Mexico	16,313	17,573	17,209	14,172	17,041

See footnotes at end of table.

TABLE 10—Continued
RAW STEEL: WORLD PRODUCTION, BY COUNTRY[1, 2, 3]

(Thousand metric tons)

Country[4]	2006	2007	2008	2009	2010
Moldova	675	995	885	425	240 [e]
Montenegro	163	174	202	90 [r]	95 [e]
Morocco	314	314	478	480 [e]	480 [e]
Netherlands	6,372	7,368	6,853	5,194	6,651
New Zealand	862	845	853	765 [r]	850 [e]
Norway[e]	679	680	590	591 [6]	600
Pakistan	933 [r]	1,090	1,100	1,100 [e]	1,100 [e]
Paraguay	118	132	130	130 [e]	130 [e]
Peru[e]	896 [6]	881 [6]	1,150	1,200	1,200
Philippines	558	718	711	700 [e]	700 [e]
Poland	9,992	10,621	9,727	7,129 [r]	8,008
Portugal[e]	1,400	1,400	1,400	1,400	1,400
Qatar	1,003	1,147	1,406	1,400 [r]	2,000
Romania	6,266	6,261	5,035	2,761 [r]	3,896
Russia	70,816	72,389	68,700	59,166	66,700 [e]
Saudi Arabia[e]	3,974 [6]	4,644 [6]	4,670	4,700	5,000
Serbia	1,837	1,478	1,662	1,061 [r]	1,254
Singapore[e]	607	620	600	620	650
Slovakia	5,094	5,100	4,489	3,747	4,588
Slovenia	627	638	642	430 [r]	606
South Africa	9,718	9,098	8,269	7,484	8,480
Spain	18,391	18,999	19,048	19,100 [e]	19,100 [e]
Sri Lanka[e]	30	30	30	30	30
Sweden[e]	5,435 [6]	5,673 [6]	5,500	5,000	5,000
Switzerland	1,252	1,264	1,260	981	1,000
Syria[e]	70	70	70 [6]	70	70
Taiwan	19,203	20,883	19,222	15,566	20,498
Thailand	4,914 [r]	5,565 [r]	5,211 [r]	3,645 [r]	4,000 [e]
Trinidad and Tobago	674	682	489 [r]	417 [r]	572
Tunisia	68	61	82	155	180
Turkey	23,308	25,750	26,809 [r]	25,000 [e]	30,000 [e]
Uganda[e]	30	30	30	25	28
Ukraine	40,899	42,830	37,107	29,757	33,559
United Arab Emirates[e]	70	90	90	90	90
United Kingdom	13,931	14,300	13,538	10,080	9,709
United States	98,200	98,100	91,900	59,400	80,500
Uruguay	57	71	70	70 [e]	70 [e]
Uzbekistan	730 [e]	740 [e]	686	716	745 [e]
Venezuela	4,864	5,005	4,240	5,000 [e]	5,000
Vietnam	1,869	2,024	2,250	2,700 [r]	2,700
Zimbabwe[e]	24 [6]	23 [6]	10	10	--
Total	1,250,000	1,350,000	1,330,000	1,240,000 [r]	1,420,000

[e]Estimated. [r]Revised. -- Zero.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Steel formed in solid state after melting, suitable for further processing or sale; for some countries, includes material reported as "liquid steel," presumably measured in the molten state prior to cooling in any specific form.

[3]Table includes data available through September 8, 2011.

[4]In addition to the countries listed, Mozambique is known to have steelmaking plants, but available information is inadequate to make reliable estimates of output levels.

[5]Data for year ending June 30 of that stated.

TABLE 10—Continued
RAW STEEL: WORLD PRODUCTION, BY COUNTRY[1,2,3]

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[6] Reported figure.

[7] Excludes castings.

[8] Figures reported by the State Statistical Bureau that the Government of China considers as official statistical data.

IRON AND STEEL SCRAP

By Michael D. Fenton

Domestic survey data and tables were prepared by Hoa P. Phamdang, statistical assistant.

Steel scrap recycling conserves energy, landfill space, and raw materials. In 2010, the domestic steel industry recycled or exported for recycling nearly 69 million metric tons (Mt) of appliances, automobiles, cans, construction materials, and other steel products (G.L. Crawford, Steel Recycling Institute, unpub. data, January 11, 2011). This resulted in an overall recycling rate of about 88%. The remelting of scrap requires much less energy than does the production of iron and steel products from iron ore. Each year, steel recycling saves the energy equivalent of the electrical power needed for 1 year by approximately one-fifth of the houses in the United States (about 18 million houses). Consumption of iron and steel scrap by remelting reduces the burden on landfill disposal facilities and prevents the accumulation of abandoned steel products in the environment.

Iron and steel scrap is a vital raw material for the production of new steel and cast-iron products. The steelmaking and foundry industries in the United States are highly dependent upon the ready availability of scrap from manufacturing operations and from the recovery of products that are no longer used or needed. The steel industry has been recycling steel scrap for more than 170 years, using electric arc furnaces (EAF), which accounted for about 61% of the total raw steel produced in 2010. Consistent with international usage and Federal Government policy, the U.S. Geological Survey (USGS) reports all data on iron and steel in metric units, unless otherwise noted.

In the United States, the primary source of obsolete steel is the automobile. By weight, the typical car consists of about 65% iron and steel. The steel used in the outside shell of car bodies is made of about 29% recycled steel (G.L. Crawford, Steel Recycling Institute, unpub. data, January 11, 2011). The steel industry recovered and recycled almost 14 Mt of iron and steel from about 10.8 million end-of-life vehicles in 2010, processed through more than 300 car shredders. The recycling rate for automotive scrap was 113% in 2010. A recycling rate greater than 100% is a result of the steel industry recycling more steel from automobiles than was used in the production of new vehicles. About 8,300 vehicle dismantlers in North America resold parts.

The annual average recycling rate of obsolete appliance scrap continued at a high of about 90% in 2010, the same as that of 2009 (G.L. Crawford, Steel Recycling Institute, unpub. data, November 1, 2011). During 2010, almost 2.7 Mt of steel was recovered from recycled appliances, an increase of about 5% compared with that of 2009. The typical appliance consists of about 68% steel, and the steel used in appliances is made with a minimum of 29% recycled steel. The recycling rate of steel containers increased to more than 67% in 2010 from 15% in 1983 (G.L. Crawford, Steel Recycling Institute, unpub. data, November 1, 2011). More than 1.4 Mt of steel containers was recycled. The estimated rate of recycling of structural beams and plates in 2004 through 2010 was about 98%, an increase from 85% in 1997. Recycling rates for reinforcement bar and other materials increased to 70% in 2010 from 40% in 1997.

Minimills, in which EAFs are used, consumed direct-reduced iron (DRI) to improve steel quality, and integrated steelmakers continued to use small quantities of DRI in blast furnaces as a process coolant. Minimills often used a feed mix that has equal proportions of DRI, pig iron, and scrap. Raw steel production in the minimill industry increased by 34% during 2010 (American Iron and Steel Institute, 2011, p. 72) (table 3), while DRI production remained at zero, as in 2009 (Midrex Technologies, Inc., 2011).

Consumption

Domestic data for ferrous scrap were derived from voluntary monthly or annual surveys of U.S. scrap-consuming operations by the USGS. About 62% of the known manufacturers of pig iron and raw steel responded to the surveys. Their response represented about 64% of the 53 Mt of ferrous scrap consumed by this class of consumers (table 1). The remaining 36% of scrap consumption was estimated based on prior reports. Of the iron foundries, manufacturers of steel castings, and miscellaneous users, about 58% of the surveyed establishments responded to the annual survey, which represented about 59% of scrap consumed by this class of consumers. Total consumption for these two classes of consumers included estimates based on statistical methods and prior reports plus actual survey responses. Actual survey data accounted for about 59% of total ferrous scrap consumption by all classes of scrap consumers.

In 2010, brokers, dealers, and other outside sources supplied domestic consumers with 50.3 Mt of all types of ferrous scrap at an estimated average delivered value of $16.4 billion, and exported 20.5 Mt (excluding used rails for rerolling and other uses, and ships, boats, and other vessels for scrapping) valued at $8.4 billion (tables 1, 8, 11). Raw steel production was 80.5 Mt in 2010 compared with 59.4 Mt in 2009 (American Iron and Steel Institute, 2011, p. 73).

The share of raw steel produced by EAF and basic oxygen furnaces was 61% and 39%, respectively. In 2010, continuous cast steel production represented 97% of total raw steel production; this was slightly less than that of 2009. Raw steel production capability increased to 114 Mt from 113 Mt in 2009 (American Iron and Steel Institute, 2011, p. 75). The capability utilization index increased to 70.4% in 2009 from 52.4% in 2010.

Steel mills accounted for 91% of all scrap received from brokers, dealers, and other outside sources; iron foundries and miscellaneous users received 7%; and steel foundries received 2% (table 1). Apparent total domestic consumption of ferrous scrap was 46.8 Mt, as measured by net receipts (total external receipts minus shipments) and 10 Mt of home scrap (table 2). Stocks of ferrous scrap at consumer plants increased by 16% to 3.9 Mt (table 1). Total domestic consumption was 60.1 Mt, 13% more than that of 2009 (table 1). The total market for U.S.-produced scrap (net receipts plus exports minus imports) was 67.0 Mt, compared with 62.8 Mt in 2009 (table 1). Feedstock used in electric furnaces by all iron and steel product manufacturers comprised scrap, 89%; pig iron, 9%; and DRI, 2% (table 4). Total consumption of DRI was 10% more than that of 2009 (table 1). Net shipments of all grades of steel mill products were about 75.7 Mt, which was an increase of 34% from the 56.4 Mt shipped in 2009 (American Iron and Steel Institute, 2011, p. 25).

Prices

The average composite delivered price of No. 1 heavy-smelting steel scrap in 2010, calculated from prices per long ton published monthly by American Metal Market, was $326.34 per metric ton. The price ranged from a low of $290.69 per ton in January to a high of $365.97 per ton in December (table 8). The average composite delivered price of No. 1 heavy-melting steel scrap, calculated from prices per long ton published weekly in the Iron Age Scrap Price Bulletin, was $318.71 per metric ton; the price ranged from a low of $275.54 per ton in December to a high of $367.68 per ton in April.

Based on weekly quotations by Iron Age Scrap Price Bulletin for 18–8 (18% chromium, 8% nickel) stainless steel scrap (bundles and solids) delivered to consumers in the Pittsburgh, PA, area, the average price was about $2,187 per gross ton in 2010, an increase of 41% compared with that of 2009.

The unit value of total ferrous scrap exports (excluding used rails for rerolling and other uses, and ships, boats, and other vessels for scrapping) increased by 29% to about $408 per metric ton compared with that of 2009 (table 11). The unit value of total imports increased by 38% to about $377 per metric ton, compared with that of 2009 (table 14).

Foreign Trade

Foreign trade valuation continued to be reported on a free-alongside-ship basis for exports and on a customs-value basis for imports. In 2010, the U.S. trade surplus for all classes of ferrous scrap (including used rails for rerolling and other uses, and ships, boats, and other vessels for scrapping) was 16.8 Mt valued at about $7.0 billion (tables 11, 14). This represented a decrease of 14% in quantity and an increase of 10% in value compared with the 2009 surplus of 19.4 Mt valued at $6.3 billion.

World Review

Iron and steel scrap is an important raw material for the steel and foundry industries. Because scrap comes from such sources as discarded cars and consumer durables, industrial machinery, manufacturing operations, and old buildings, the relatively mature industrialized economies are generally the main exporters of scrap to lesser developed steelmaking countries.

The United States exported more iron and steel scrap in 2010 than any other country, followed by, in decreasing order of export tonnage, Germany, France, Japan, and Canada (World Steel Association, 2011a, p. 115–116). The leading importing nations were, in decreasing order of import tonnage, Turkey, the United States, the Republic of Korea, China, and Germany (World Steel Association, 2011a, p. 117–118).

Outlook

Because of the close interdependence of the steelmaking and ferrous scrap industries, forecast of the global steel industry in the context of the global economy serves as the bellwether of the scrap industry.

The World Bank's forecast of global gross domestic product (GDP) growth for 2011, 2012, and 2013 was 3.2%, 3.6%, and 3.6%, respectively (World Bank, The, 2011). The International Monetary Fund's forecast of world GDP growth for 2011 and 2012 was 4.3% and 4.5%, respectively (International Monetary Fund, 2011). The U.S. Federal Reserve Bank's forecast for the U.S. 2011 GDP growth rate was between 3.4% and 3.9%, and between 3.5% and 4.4% for 2012 (Board of Governors of the Federal Reserve System, 2011). The GDP growth for China was projected to be 9.3% and 8.7% in 2011 and 2012, respectively, and that of India was projected to be 8.0% and 8.4% for those years, respectively (World Bank, The, 2011).

World apparent steel consumption (ASC) was expected to increase by 6% to 1,359 Mt during 2011, after increasing by 13% in 2010, and then increase by 6% in 2012, to reach a historic high of 1,440 Mt (World Steel Association, 2011b). China's ASC was expected to increase by 5% to 605 Mt in 2011, and then by 5% in 2012 to 635 Mt. ASC in India was expected to increase by 13% in 2011 to about 69 Mt and 14% in 2012. The U.S. ASC was expected to increase by 13% to 90 Mt in 2011. The European Union's (EU) ASC was expected to increase by 5% to 152 Mt in 2011 and increase by 4% in 2012. In Japan, the 2011 ASC was expected to decrease by 1.2% to 63 Mt, and remain at this level during 2012. The ASC of the Commonwealth of Independent States (CIS) was expected to increase by nearly 8% to 52 Mt in 2011 and then by 9% in 2012.

World capacity for DRI production in 2010 was estimated to be about 83 million metric tons per year (Mt/yr) (Midrex Technologies, Inc., 2011). DRI production worldwide reached a record of 68.7 Mt in 2010, 4.6% more than that in 2009 (Fenton, 2012) (table 9). The leading producer of DRI was India, accounting for 30% of the total, followed by, in descending order of tonnage, Iran, Venezuela, Mexico, and Saudi Arabia. At yearend 2010, additional DRI capacity of almost 20 Mt/yr was under construction in Bahrain, China, Egypt, India, Iran, Oman, Pakistan, the United Arab Emirates, and Venezuela. The leading technology was the Midrex process, followed by the HYL I and the HYL III processes.

MEPS (International) Ltd. forecast total world steel production in 2011 to be 1,568 Mt, up 11% from that in 2010, and 1,625 Mt for 2014 [MEPS (International) Ltd., 2011]. MEPS also forecast increasing steel production in 2011 in South America, the Middle East, China, the CIS, and the EU of 17%, 11%, 8%, 5%, and 4%, respectively. For China, MEPS forecast a 19% increase in steel production by 2014 compared with that in 2010.

Because the primary source of obsolete steel is the automobile, an increasing world population and increased demand for vehicles in developing countries, especially China and India, are expected to contribute to a dramatic rise in the amount of vehicle scrap created during the next 25 years, according to the Oxford Brookes University in the United Kingdom (Blanco, 2007). More vehicles are expected to be produced in the next 25 years than in the history of the motor vehicle industry through 2008.

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TABLE 1
SALIENT U.S. IRON AND STEEL SCRAP, PIG IRON, AND DIRECT-REDUCED IRON STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2006	2007	2008	2009	2010
Manufacturers of pig iron and raw steel and castings:[2]					
Ferrous scrap consumption	55,200 r	55,000 r	58,000 r	47,700 r	53,100
Pig iron consumption	36,800 r	36,500	33,600	28,300	34,100
Direct-reduced iron consumption	1,570 r	2,040	1,950	1,340	1,490
Net receipts of ferrous scrap[3]	45,700 r	46,800 r	49,800 r	39,800	45,700
Home scrap production[4]	9,140 r	8,760 r	8,720 r	7,610 r	7,720
Ending stocks of ferrous scrap, December 31	3,710 r	3,650 r	3,730 r	2,820	3,010
Manufacturers of steel castings:[5]					
Ferrous scrap consumption	1,080	1,710 r	2,080	841 r	1,810
Pig iron consumption	11	11	12	17	10
Direct-reduced iron consumption	--	--	4	14	--
Net receipts of ferrous scrap[3]	754	965	1,630	588 r	1,230
Home scrap production[4]	319	693 r	549	272 r	566
Ending stocks of ferrous scrap, December 31	79	383	503	397	629
Iron foundries and miscellaneous users:[5]					
Ferrous scrap consumption	8,300	7,940	7,760 r	4,650 r	5,180
Pig iron consumption	934 r	870 r	842 r	1,840 r	1,910
Direct-reduced iron consumption	4	4	3	3 r	3
Net receipts of ferrous scrap[3]	5,600 r	5,120 r	5,200	2,950 r	3,370
Home scrap production[4]	2,700	2,550	2,560	1,700 r	1,940
Ending stocks of ferrous scrap, December 31	420 r	413 r	416 r	127 r	256
Total, all manufacturing types:					
Ferrous scrap consumption	64,600 r	64,700 r	67,900 r	53,200 r	60,100
Pig iron consumption	37,700 r	37,400	34,400	30,200	36,000
Direct-reduced iron consumption	1,580 r	2,050	1,960	1,360	1,490
Net receipts of ferrous scrap[3]	52,100 r	52,900 r	56,600 r	43,400	50,300
Home scrap production[4]	12,200 r	12,000 r	11,800	9,580 r	10,200
Ending stocks, December 31:					
Ferrous scrap at consumer plants	4,210 r	4,440 r	4,650 r	3,350 r	3,900
Pig iron at consumer and supplier plants	787 r	771	885	505 r	415
Direct-reduced iron at consumer plants	312 r	364	435	234	161
Exports:[6]					
Ferrous scrap (includes tinplate and terneplate):[7]					
Quantity	14,900	16,500	21,500	22,400	20,500
Value	4,230,000	6,890,000	10,400,000	7,120,000	8,380,000
Pig iron, all grades:					
Quantity	813	71	51	11	2,220
Value	8,750	4,610	11,400	4,200	13,400
Direct-reduced iron, steelmaking grade:					
Quantity	(8)	(8)	1	(8)	1
Value	11	23	97	38	115
Imports for consumption:[6]					
Ferrous scrap (includes tinplate and terneplate):[7]					
Quantity	4,820	3,700	3,600	2,990	3,780
Value	1,250,000	1,040,000	1,450,000	814,000	1,420,000
Pig iron, all grades:					
Quantity	6,730	5,220	4,980	2,420	3,780
Value	1,760,000	1,660,000	2,800,000	877,000	1,540,000
Direct-reduced iron, steelmaking grade:					
Quantity	2,610	2,330	2,340	1,020	1,640
Value	417,000	519,000	971,000	304,000	607,000

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r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes manufacturers of raw steel that also produce steel castings.

[3] Net receipts of scrap is defined as receipts from brokers, dealers, and other outside sources plus receipts from other company-owned plants minus shipments.

TABLE 1—Continued

SALIENT U.S. IRON AND STEEL SCRAP, PIG IRON, AND DIRECT-REDUCED IRON STATISTICS[1]

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[4] Home scrap production includes recirculating scrap that results from current operations and obsolete home scrap.

[5] Some consumers in the "Manufacturers of steel castings" category also produce iron castings; some consumers in the "Iron foundries and miscellaneous users" category also produce steel castings.

[6] Data from U.S. Census Bureau and U.S. International Trade Commission. Export valuation is free alongside ship, and import valuation is customs value.

[7] Excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping.

[8] Less than ½ unit.

TABLE 2
U.S. CONSUMER RECEIPTS, PRODUCTION, CONSUMPTION, SHIPMENTS, AND STOCKS OF IRON AND STEEL SCRAP IN 2010 BY GRADE[1]

(Thousand metric tons)

	Receipts of scrap		Production of home scrap				
Grade	From brokers, dealers, and other outside sources	From other company-owned plants	Recirculating scrap from current operations	Obsolete scrap[2]	Consumption of purchased and home scrap	Shipments of scrap	Ending stocks, December 31
Manufacturers of pig iron and raw steel and castings:							
Carbon steel:							
Low-phosphorus plate and punchings	685	7	21	--	714	--	123
Cut structural and plate	3,340	157	650	--	4,090	2	218
No. 1 heavy-melting steel	4,650	196	1,010	1	5,760	48	347
No. 2 heavy-melting steel	5,480	157	258	W	5,840	15	331
No. 1 and electric furnace bundles	2,510	186	894	--	3,440	178	206
No. 2 and all other bundles	918	15	W	--	930	W	47
Electric furnace, 1 foot and under (not bundles)	10	--	W	--	63	W	W
Railroad rails	239	W	51	--	309	W	13
Turnings and borings	1,840	198	48	W	2,080	1	88
Slag scrap	896	86	1,080	W	1,460	583	170
Shredded or fragmentized	11,300	1,450	W	--	12,800	71	630
No. 1 busheling	4,160	116	204	--	4,490	W	203
Steel cans, post consumer	97	--	--	--	97	--	5
All other carbon steel scrap	3,970	233	1,750	W	5,670	264	257
Stainless steel scrap	846	77	362	W	1,280	4	52
Alloy steel (except stainless)	151	164	348	--	657	10	44
Ingot mold and stool scrap	--	--	82	65	58	89	12
Machinery and cupola cast iron	35	W	W	--	38	W	2
Cast-iron borings	246	4	7	--	244	W	22
Motor blocks	--	--	--	--	--	--	--
Other iron scrap	941	76	193	--	1,120	83	137
Other mixed scrap	1,390	307	250	W	1,900	57	103
Total	43,700	3,450	7,620	96	53,100	1,430	3,010
Manufacturers of steel castings:							
Carbon steel:							
Low-phosphorus plate and punchings	607	1	222	--	811	--	300
Cut structural and plate	50	--	5	--	55	--	--
No. 1 heavy-melting steel	16	--	--	--	17	--	3
No. 2 heavy-melting steel	W	--	--	--	W	--	--
No. 1 and electric furnace bundles	W	--	--	--	W	--	W
No. 2 and all other bundles	--	--	--	--	--	--	--
Electric furnace, 1 foot and under (not bundles)	5	--	3	--	8	--	--
Railroad rails	W	--	W	--	W	--	W
Turnings and borings	25	--	10	--	34	W	1
Slag scrap	4	--	W	--	W	--	W
Shredded or fragmentized	24	--	--	--	24	--	--
No. 1 busheling	36	--	--	--	36	--	2
Steel cans, post consumer	--	--	--	--	--	--	--
All other carbon steel scrap	3	--	45	--	49	--	--
Stainless steel scrap	237	--	19	W	296	1	94
Alloy steel (except stainless)	53	2	28	W	84	--	66
Ingot mold and stool scrap	W	--	W	--	W	W	W
Machinery and cupola cast iron	--	--	--	--	--	--	--
Cast-iron borings	--	--	--	--	--	--	--
Motor blocks	--	--	--	--	--	--	--
Other iron scrap	1	--	--	--	2	--	--
Other mixed scrap	31	--	W	W	45	--	3
Total	1,230	3	552	14	1,810	2	629

See footnotes at end of table.

TABLE 2—Continued

U.S. CONSUMER RECEIPTS, PRODUCTION, CONSUMPTION, SHIPMENTS, AND STOCKS OF IRON AND STEEL SCRAP IN 2010 BY GRADE[1]

(Thousand metric tons)

	Receipts of scrap		Production of home scrap				
Grade	From brokers, dealers, and other outside sources	From other company-owned plants	Recirculating scrap from current operations	Obsolete scrap[2]	Consumption of purchased and home scrap	Shipments of scrap	Ending stocks, December 31
Iron foundries and miscellaneous users:							
Carbon steel:							
Low-phosphorus plate and punchings	643	W	147	--	791	1	4
Cut structural and plate	510	2	46	14	569	--	18
No. 1 heavy-melting steel	90	W	W	--	147	--	5
No. 2 heavy-melting steel	85	--	W	23	110	--	1
No. 1 and electric furnace bundles	68	--	--	--	68	--	1
No. 2 and all other bundles	5	--	W	--	2	W	--
Electric furnace, 1 foot and under (not bundles)	92	--	71	84	170	--	78
Railroad rails	28	W	W	--	28	W	1
Turnings and borings	W	--	1	--	28	1	18
Slag scrap	W	--	2	--	W	2	--
Shredded or fragmentized	633	--	19	--	603	W	68
No. 1 busheling	305	--	8	--	314	--	7
Steel cans, post consumer	W	--	--	--	W	--	--
All other carbon steel scrap	52	--	56	W	108	1	4
Stainless steel scrap	2	--	--	W	3	--	--
Alloy steel (except stainless)	13	--	1	--	14	W	1
Ingot mold and stool scrap	W	W	W	--	W	W	W
Machinery and cupola cast iron	401	W	114	W	540	5	36
Cast-iron borings	47	10	9	--	65	--	1
Motor blocks	121	W	470	--	593	W	2
Other iron scrap	172	23	750	--	924	9	23
Other mixed scrap	24	W	30	--	72	5	--
Total	3,360	47	1,790	151	5,180	37	256
Grand total, all manufacturing types:							
Carbon steel:							
Low-phosphorus plate and punchings	1,940	8	390	--	2,320	W	427
Cut structural and plate	3,900	159	702	14	4,720	2	237
No. 1 heavy-melting steel	4,760	198	1,060	1	5,930	48	355
No. 2 heavy-melting steel	5,580	157	258	W	5,960	15	333
No. 1 and electric furnace bundles	2,580	186	894	--	3,510	178	208
No. 2 and all other bundles	922	15	8	--	932	4	47
Electric furnace, 1 foot and under (not bundles)	107	--	153	84	240	W	78
Railroad rails	267	23	53	--	337	5	15
Turnings and borings	1,910	198	59	--	2,150	2	106
Slag scrap	905	86	1,080	W	1,470	585	173
Shredded or fragmentized	11,900	1,450	351	--	13,500	73	699
No. 1 busheling	4,500	116	213	--	4,840	--	212
Steel cans, post consumer	99	--	--	--	99	--	5
All other carbon steel scrap	4,020	233	1,850	10	5,830	265	261
Stainless steel scrap	1,090	77	381	6	1,580	5	147
Alloy steel (except stainless)	217	165	377	W	755	10	111
Ingot mold and stool scrap	142	W	301	65	416	91	174
Machinery and cupola cast iron	436	W	116	W	579	6	38
Cast-iron borings	293	14	16	--	308	--	23
Motor blocks	121	W	470	--	593	W	2
Other iron scrap	1,110	99	943	--	2,050	92	161
Other mixed scrap	1,440	308	280	23	2,020	63	86
Total	48,300	3,500	9,960	261	60,100	1,470	3,900

W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Obsolete home scrap includes ingot molds, stools, and scrap from old equipment and buildings.

TABLE 3
U.S. CONSUMER RECEIPTS, PRODUCTION, CONSUMPTION, SHIPMENTS, AND STOCKS OF PIG IRON AND DIRECT-REDUCED IRON IN 2010[1]

(Thousand metric tons)

	Receipts	Production	Consumption	Shipments	Stocks, December 31
Manufacturers of pig iron, raw steel, and castings:					
Pig iron	9,630 [2]	24,500	34,100	88	390
Direct-reduced iron (DRI)	1,500 [3]	--	1,490	W	160
Manufacturers of steel castings:					
Pig iron	11	(4)	10	(4)	(4)
DRI	(4)	--	--	--	(4)
Iron foundries and miscellaneous users:					
Pig iron	1,910	3	1,910	3	25
DRI	3	--	3	--	(4)
Total, all manufacturing types:					
Pig iron	11,600	24,500	36,000	92	415
DRI	1,500	--	1,490	W	161

W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes 1.69 million metric tons purchased by electric furnace steel producers.

[3] Includes 49,800 metric tons purchased by integrated steel producers.

[4] Less than ½ unit.

TABLE 4
U.S. CONSUMPTION OF IRON AND STEEL SCRAP, PIG IRON, AND DIRECT-REDUCED IRON IN 2010, BY TYPE OF FURNACE OR OTHER USE[1]

(Thousand metric tons)

	Manufacturers of pig iron and raw steel and castings			Manufacturers of steel castings			Iron foundries and miscellaneous users			Total, all manufacturing types		
	Scrap	Pig iron	DRI[2]	Scrap	Pig iron	DRI[2]	Scrap	Pig iron	DRI[2]	Scrap	Pig iron	DRI[2]
Blast furnace	1,200	--	50	--	--	--	--	--	--	1,200	--	50
Basic oxygen process	9,860	31,200	341	--	--	--	--	--	--	9,860	31,200	341
Electric furnace	41,900	2,880	1,100	1,810	10	--	3,800	1,840	3	47,500	4,740	1,100
Cupola furnace	157	--	--	--	--	--	1,290	55	--	1,450	55	--
Other[3]	4	--	--	2	--	--	79	16	--	85	16	--
Direct castings[4]	--	36	--	--	--	--	--	--	--	--	36	--
Total	53,100	34,100	1,490	1,810	10	--	5,180	1,910	3	60,100	36,000	1,490

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Direct-reduced iron.

[3] Includes air furnaces.

[4] Includes ingot molds and stools.

TABLE 5

IRON AND STEEL SCRAP SUPPLY AVAILABLE FOR CONSUMPTION IN 2010, BY REGION AND STATE[1, 2]

(Thousand metric tons)

Region and State	Receipts of scrap: From brokers, dealers, and other outside sources	Receipts of scrap: From other company-owned plants	Production of home scrap: Recirculating scrap resulting from current operations	Production of home scrap: Obsolete scrap[3]	Shipments of scrap[4]	New supply available for consumption
New England and Middle Atlantic:						
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	20	(5)	15	W	W	36
New Jersey and New York	1,780	--	84	W	W	1,830
Pennsylvania	3,320	723	1,830	W	59	5,890
Total	5,120	723	1,920	80	92	7,750
North Central:						
Illinois	1,720	(5)	147	57	W	1,860
Indiana	3,950	298	1,810	(5)	362	5,690
Iowa, Nebraska, South Dakota	2,060	29	133	(5)	W	2,230
Kansas and Missouri	13	5	19	--	(5)	36
Michigan	2,090	(5)	956	(5)	562	2,480
Minnesota	406	142	22	--	22	548
Ohio	5,990	398	1,050	24	92	7,370
Wisconsin	1,700	2	989	--	5	2,690
Total	17,900	876	5,120	82	1,110	22,900
South Atlantic:						
Delaware and Maryland	962	W	W	--	W	1,300
Florida and Georgia	697	--	W	--	W	702
North Carolina and South Carolina	3,070	W	564	W	(5)	3,850
Virginia and West Virginia	1,770	290	268	W	W	2,300
Total	6,500	521	1,220	W	92	8,150
South Central:						
Alabama and Mississippi	4,270	W	243	--	W	4,550
Arkansas, Louisiana, Oklahoma	4,320	W	399	W	W	4,880
Kentucky and Tennessee	3,310	W	265	--	W	3,780
Texas	2,730	664	178	W	95	3,480
Total	14,600	1,080	1,090	6	102	16,700
Mountain and Pacific:						
Arizona, Colorado, Idaho, Utah	1,540	W	57	W	W	1,690
California, Oregon, Washington	2,550	W	550	W	W	3,320
Total	4,090	306	607	94	77	5,020
Grand total	48,300	3,500	9,960	261	1,470	60,500

W Withheld to avoid disclosing company proprietary data; included in "Total" or "Grand total." -- Zero.

[1] Supply available for consumption is a net figure computed by adding production to receipts and deducting scrap shipped during the year. The difference in stock levels at the beginning and end of the year is not taken into consideration.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Obsolete scrap includes ingot molds, stools, and scrap from old equipment, buildings, etc.

[4] Includes scrap shipped, transferred, or otherwise disposed of during the year.

[5] Less than ½ unit.

TABLE 6

U.S. CONSUMPTION OF IRON AND STEEL SCRAP AND PIG IRON IN 2010, BY REGION AND STATE[1, 2, 3]

(Thousand metric tons)

Region and State	Manufacturers of pig iron and raw steel and castings		Manufacturers of steel castings		Iron foundries and miscellaneous users		Total, all manufacturing types	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
New England and Middle Atlantic:								
Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont	1,720	21	8	--	134	6	1,860	28
Pennsylvania	5,540	3,230	154	1	187	17	5,880	3,250
Total	7,250	3,250	162	1	321	23	7,730	3,280
North Central:								
Illinois	1,500	W	24	(4)	330	71	1,860	2,260
Indiana	5,360	11,800	62	(4)	262	46	5,690	11,800
Iowa, Kansas, Minnesota, Missouri, Nebraska, South Dakota, Wisconsin	3,270	W	53	(4)	2,100	1,650	5,420	1,770
Michigan	1,900	W	29	--	546	24	2,470	4,070
Ohio	6,410	6,470	67	(4)	749	52	7,220	6,530
Total	18,400	24,600	235	1	3,980	1,840	22,700	26,400
South Atlantic:								
Delaware, Maryland, Virginia, West Virginia	W	W	W	(4)	W	W	3,640	1,580
Florida, Georgia, North Carolina, South Carolina	W	W	W	--	W	W	4,550	94
Total	7,250	1,670	612	(4)	320	3	8,190	1,670
South Central:								
Alabama, Kentucky, Mississippi, Tennessee	7,570	4,060	W	(4)	W	W	8,400	W
Arkansas, Louisiana, Oklahoma	4,800	467	W	--	W	W	4,810	W
Texas	3,270	--	31	7	110	16	3,410	23
Total	15,600	4,530	731	7	258	38	16,600	4,570
Mountain and Pacific:								
Arizona, Colorado, Idaho, Utah	1,590	W	2	(4)	73	(4)	1,670	37
California, Oregon, Washington	2,920	80	68	(4)	220	4	3,200	47
Total	4,510	80	70	(4)	293	4	4,870	84
Grand total	53,100	34,100	1,810	10	5,180	1,910	60,100	36,000

W Withheld to avoid disclosing company proprietary data; included in "Total" or "Grand total." -- Zero.

[1] Includes recirculating scrap resulting from current operations and home-generated obsolete scrap.

[2] Includes molten pig iron used for ingot molds and direct castings.

[3] Data are rounded to no more than three significant digits; may not add to totals shown.

[4] Less than ½ unit.

TABLE 7
U.S. CONSUMER STOCKS OF IRON AND STEEL SCRAP AND PIG IRON, DECEMBER 31, 2010, BY REGION AND STATE[1]

(Thousand metric tons)

Region and State	Carbon steel[2]	Stainless steel	Alloy steel[3]	Cast iron[4]	Other grades of scrap	Total scrap	Pig iron
New England and Middle Atlantic:							
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	1	(5)	--	(5)	W	(5)	(5)
New Jersey and New York	64	(5)	--	2	W	66	2
Pennsylvania	233	13	12	16	3	277	3
Total	297	13	12	18	4	344	5
North Central:							
Illinois	71	(5)	(6)	3	W	77	10
Indiana	390	3	5	15	W	419	153
Iowa, Kansas, Missouri, Nebraska, South Dakota	110	W	W	2	--	117	8
Michigan	98	(6)	W	7	1	106	3
Minnesota and Wisconsin	104	W	(6)	5	W	111	7
Ohio	466	34	19	70	W	589	55
Total	1,240	40	27	102	12	1,420	236
South Atlantic:							
Delaware, Maryland, Virginia, West Virginia	223	W	W	W	--	W	W
Florida, Georgia, North Carolina, South Carolina	309	W	W	W	--	W	W
Total	532	70	60	246	--	901	66
South Central:							
Alabama, Kentucky, Mississippi, Tennessee	313	W	W	14	W	350	59
Arkansas, Louisiana, Oklahoma	277	W	W	2	--	287	37
Texas	213	1	W	6	W	221	(5)
Total	803	23	9	22	W	858	96
Mountain and Pacific:							
Arizona, Colorado, Idaho, Utah	55	(5)	(5)	(5)	W	97	3
California, Oregon, Washington	227	(5)	2	9	W	276	9
Total	282	1	2	9	52	373	12
Grand total	3,150	147	111	397	86	3,900	415

W Withheld to avoid disclosing company proprietary data; included in "Total" or "Grand total." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes rerolling rails.

[3] Excludes stainless steel.

[4] Includes borings.

[5] Less than ½ unit.

[6] Withheld to avoid disclosing company proprietary data; included in "North Central Total" of "Total scrap."

TABLE 8
U.S. AVERAGE MONTHLY PRICE AND COMPOSITE PRICE FOR NO. 1 HEAVY-MELTING STEEL, WITH ANNUAL AVERAGES[1]

(Dollars per metric ton)

Period	Chicago, IL	Philadelphia, PA	Pittsburgh, PA	Composite price
2009,[r] average	230.07	208.36	201.48	213.30
2010:				
January	292.93	276.88	302.26	290.69
February	300.18	274.80	310.03	295.00
March	347.26	323.51	350.67	340.48
April	354.31	360.13	380.71	365.05
May	333.40	340.54	332.42	335.45
June	329.71	301.08	329.71	320.17
July	300.18	274.17	308.16	294.17
August	320.76	314.50	323.89	319.72
September	341.66	345.69	338.85	342.07
October	319.17	307.92	316.12	314.40
November	332.66	327.99	338.07	332.91
December	374.00	349.14	374.78	365.97
Average	328.85	316.36	333.81	326.34

[r] Revised.

[1] Calculated by the U.S. Geological Survey from prices published in American Metal Market.

TABLE 9

U.S. EXPORTS OF IRON AND STEEL SCRAP, BY COUNTRY[1, 2]

(Thousand metric tons and thousand dollars)

Country	2009		2010	
	Quantity	Value	Quantity	Value
Argentina	1	369	4	1,450
Australia	(3)	1,520	(3)	262
Austria	(3)	1,480	1	2,860
Bahamas, The	(3)	119	(3)	103
Bangladesh	91	25,100	37	13,800
Belgium	6	5,690	10	20,100
Brazil	64	19,000	61	20,600
Canada	971	235,000	1,360	417,000
Chile	1	393	1	453
China	6,210	2,500,000	3,210	1,800,000
Colombia	(3)	233	(3)	560
Costa Rica	(3)	161	1	164
Dominican Republic	2	642	4	960
Ecuador	(3)	47	31	11,300
Egypt	361	90,500	650	228,000
El Salvador	(3)	41	1	499
Finland	30	41,600	43	91,700
France	1	1,490	8	3,010
Germany	12	2,530	9	3,540
Greece	224	53,900	72	21,800
Guyana	(3)	72	1	271
Hong Kong	100	65,800	96	83,500
India	1,580	419,000	976	347,000
Indonesia	369	101,000	388	145,000
Israel	(3)	325	3	959
Italy	48	17,300	179	71,200
Jamaica	(3)	108	1	290
Japan	69	104,000	172	170,000
Kenya	(3)	82	1	284
Korea, Republic of	3,110	939,000	2,820	1,030,000
Malaysia	689	189,000	803	311,000
Mexico	668	159,000	666	213,000
Netherlands	5	5,610	23	19,500
Netherlands Antilles	1	127	(3)	47
New Caledonia	(3)	2,980	1	3,740
Pakistan	333	83,900	174	70,100
Peru	155	42,400	280	98,200
Portugal	25	4,460	(3)	3
Saudi Arabia	1	538	(3)	227
Singapore	38	9,970	8	2,880
Spain	41	29,100	20	32,100
Sweden	13	6,160	3	9,060
Switzerland	55	15,700	(3)	79
Taiwan	2,230	722,000	2,820	1,160,000
Thailand	459	120,000	562	204,000
Trinidad and Tobago	12	4,640	1	496
Turkey	3,680	894,000	4,350	1,530,000
United Arab Emirates	1	493	4	1,690
United Kingdom	4	6,260	6	7,750
Uruguay	(3)	74	1	118
Venezuela	1	435	16	7,270
Vietnam	750	193,000	645	221,000
Other	8 [r]	3,030 [r]	6	4,460
Total	22,400	7,120,000	20,500	8,380,000

See footnotes at end of table.

TABLE 9—Continued

U.S. EXPORTS OF IRON AND STEEL SCRAP, BY COUNTRY[1, 2]

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[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping. Export valuation is free alongside ship. The United States exported scrap to 92 countries in 2009 and 93 countries in 2010.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10
U.S. EXPORTS OF IRON AND STEEL SCRAP, BY CUSTOMS DISTRICT[1,2]

(Thousand metric tons and thousand dollars)

Customs district	2009		2010	
	Quantity	Value	Quantity	Value
Baltimore, MD	494	158,000	264	102,000
Boston, MA	1,270	324,000	1,040	360,000
Buffalo, NY	168	45,200	316	120,000
Charleston, SC	167	79,800	160	94,300
Charlotte, NC	51	26,200	21	21,500
Chicago, IL	22	6,230	14	5,400
Cleveland, OH	2	702	5	1,810
Columbia-Snake, OR	1,220	346,000	1,270	466,000
Detroit, MI	210	71,800	295	86,700
Duluth, MN	55	14,500	75	22,700
El Paso, TX	14	3,110	25	7,070
Great Falls, MT	9	1,990	8	2,110
Honolulu, HI	140	38,800	171	58,300
Houston-Galveston, TX	914	278,000	889	340,000
Laredo, TX	418	99,200	347	113,000
Los Angeles, CA	4,330	1,730,000	4,000	2,030,000
Miami, FL	404	129,000	482	166,000
Mobile, AL	112	49,000	97	47,100
New Orleans, LA	2,230	549,000	1,290	477,000
New York, NY	3,110	1,040,000	2,580	1,170,000
Nogales, AZ	15	4,340	(3)	6
Norfolk, VA	439	176,000	360	166,000
Ogdensburg, NY	100	19,900	47	15,000
Pembina, ND	295	83,100	430	148,000
Philadelphia, PA	1,400	356,000	919	321,000
Portland, ME	129	35,600	173	65,000
Providence, RI	374	90,900	449	155,000
San Diego, CA	17	3,360	29	7,620
San Francisco, CA	1,760	542,000	2,120	798,000
San Juan, PR	294	69,500	339	92,300
Savannah, GA	507	237,000	443	247,000
Seattle, WA	1,020	317,000	1,190	450,000
St. Albans, VT	35	8,750	71	22,300
Tampa, FL	583	168,000	505	184,000
Other	116	15,900	111	16,500
Total	22,400	7,120,000	20,500	8,380,000

[1] Excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping. Export valuation is free alongside ship.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 11

U.S. EXPORTS OF IRON AND STEEL SCRAP, BY GRADE[1, 2]

(Thousand metric tons and thousand dollars)

Grade	2009		2010	
	Quantity	Value	Quantity	Value
No. 1 heavy-melting scrap	5,840	1,520,000	5,650	1,940,000
No. 2 heavy-melting scrap	903	230,000	1,020	331,000
No. 1 bundles	311	79,300	326	80,900
No. 2 bundles	55	14,600	53	21,900
Shredded steel scrap	8,500	2,190,000	7,440	2,640,000
Borings, shovelings, and turnings	106	19,800	62	10,500
Cut plate and structural	1,320	359,000	825	302,000
Tinned iron or steel	112	54,000	82	52,400
Remelting scrap ingots	27	35,000	27	34,200
Stainless steel scrap	1,130	777,000	937	936,000
Other alloy steel scrap	1,280	900,000	916	840,000
Other steel scrap[3]	2,170	718,000	2,680	1,000,000
Iron scrap	668	223,000	517	197,000
Total	22,400	7,120,000	20,500	8,380,000
Ships, boats, and other vessels for scrapping	4	773	4	743
Used rails for rerolling and other uses[4]	59	38,700	49	41,000
Grand total	22,500	7,160,000	20,600	8,420,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Export valuation is free alongside ship.

[3] Includes tinplate and terneplate.

[4] Includes mixed (used plus new) rails. More information can be found in table 15.

Source: U.S. Census Bureau.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF IRON AND STEEL SCRAP, BY COUNTRY[1, 2]

(Thousand metric tons and thousand dollars)

	2009		2010	
Country	Quantity	Value	Quantity	Value
Argentina	4	737	3	2,310
Bahamas, The	3	599	9	2,560
Belgium	--	--	(3)	248
Brazil	3	2,670	1	1,790
Canada	2,400	611,000	2,700	964,000
Cayman Islands	(3)	32	2	647
China	(3)	281	(3)	171
Colombia	1 [r]	1,120	(3)	167
Denmark	26	6,290	--	--
Dominican Republic	(3)	222	(3)	471
Egypt	1	637	1	1,230
France	(3)	203	1	479
Germany	54	14,400	76	28,900
Guadeloupe	3	182	--	--
Guatemala	(3)	255	(3)	1,060
Israel	(3)	49	1	976
Japan	2	695	2	1,110
Korea, Republic of	2	628	1	1,450
Malaysia	(3)	103	1	881
Mexico	207	83,900	439	197,000
Netherlands	76	21,100	136	49,700
Netherlands Antilles	1	89	(3)	12
Peru	(3)	30	1	522
Singapore	(3)	861	3	776
Spain	(3)	281	--	--
Sweden	100	27,300	117	38,800
Taiwan	1	2,690	4	8,900
Trinidad and Tobago	(3)	164	(3)	1,080
United Kingdom	101	33,500	274	106,000
Other	6 [r]	3,350 [r]	6	6,520
Total	2,990	814,000	3,780	1,420,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping. Import valuation is customs value.
The United States imported scrap from 47 countries (revised) in 2009 and 57 countries in 2010.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF IRON AND STEEL SCRAP, BY CUSTOMS DISTRICT[1, 2]

(Thousand metric tons and thousand dollars)

	2009		2010	
Customs district	Quantity	Value	Quantity	Value
Baltimore, MD	2	1,240	(3)	609
Buffalo, NY	596	185,000	518	282,000
Charleston, SC	178	44,300	224	83,800
Chicago, IL	15	1,290	2	1,270
Cleveland, OH	(3)	427	1	2,760
Columbia-Snake, OR	36	6,570	34	9,890
Detroit, MI	644	157,000	974	363,000
Duluth, MN	52	13,700	29	14,500
El Paso, TX	35	10,200	77	28,600
Great Falls, MT	93	19,700	183	58,600
Houston-Galveston, TX	3	7,680	3	9,770
Laredo, TX	84	46,700	156	109,000
Los Angeles, CA	2	3,430	7	11,500
Miami, FL	5	1,210	8	1,660
Mobile, AL	65	21,200	61	23,700
New Orleans, LA	138	41,300	299	107,000
New York, NY	(3)	641	4	1,900
Nogales, AZ	11	3,730	11	3,940
Norfolk, VA	(3)	109	1	1,470
Ogdensburg, NY	38	15,600	29	37,100
Pembina, ND	25	11,400	35	21,400
Philadelphia, PA	(3)	174	17	7,190
Portland, ME	7	2,570	8	5,710
San Diego, CA	79	21,900	195	54,400
Seattle, WA	878	195,000	889	173,000
Tampa, FL	3	552	8	2,220
Other	3	858 [r]	3	1,410
Total	2,990	814,000	3,780	1,420,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes used rails for rerolling and other uses and ships, boats, and other vessels for scrapping. Import valuation is customs value.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF IRON AND STEEL SCRAP, BY CLASS[1, 2]

(Thousand metric tons and thousand dollars)

Class	2009		2010	
	Quantity	Value	Quantity	Value
No. 1 heavy-melting scrap	185	37,900	163	48,700
No. 2 heavy-melting scrap	28	5,510	70	18,400
No. 1 bundles	715	186,000	1,190	457,000
No. 2 bundles	37	5,430	34	6,360
Shredded steel scrap	452	78,500	441	98,200
Borings, shovelings, and turnings	53	10,100	94	21,400
Cut plate and structural	149	29,600	174	43,700
Tinned iron or steel	27	5,190	68	14,300
Remelting scrap ingots	(3)	327	(3)	190
Stainless steel scrap	124	138,000	195	305,000
Other alloy steel scrap	558	193,000	740	240,000
Other steel scrap[4]	479	90,300	469	123,000
Iron scrap	184	34,400	142	42,300
Total	2,990	814,000	3,780	1,420,000
Ships, boats, and other vessels for scrapping	(3)	79	(3)	226
Used rails for rerolling and other uses[5]	57	17,700	53	23,700
Grand total	3,050	831,000	3,830	1,440,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Import valuation is customs value.

[3] Less than ½ unit.

[4] Includes tinplate and terneplate.

[5] Includes mixed (used plus new) rails. More information can be found in table 16.

Source: U.S. Census Bureau.

TABLE 15
U.S. EXPORTS OF USED RAILS FOR REROLLING AND OTHER USES, BY COUNTRY[1, 2]

Country	2009		2010	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Anguilla	121	$127	--	--
Antigua and Barbuda	23	51	(3)	$4
Argentina	5	13	10	22
Aruba	34	33	--	--
Australia	534	759	1,760	2,460
Bahamas, The	57	89	106	143
Barbados	88	74	30	73
Bermuda	6	7	28	26
Brazil	26	34	28	62
British Virgin Islands	70	109	--	--
Canada	17,000	15,100	13,200	12,600
Cayman Islands	53	58	15	36
Chile	781	956	161	270
China	4,970	1,570	169	154
Colombia	342	588	18	41
Costa Rica	4	4	--	--
Denmark	--	--	24	99
Dominican Republic	561	633	981	1,010
Guatemala	--	--	23	39
Honduras	27	46	--	--
Hungary	--	--	12	10
India	10	9	79	142
Ireland	128	114	130	178
Italy	3	11	18	116
Jamaica	--	--	37	60
Japan	37	36	201	168
Korea, Republic of	4	3	3	20
Malaysia	13	11	(3)	5
Mexico	29,300	15,700	27,800	19,900
Netherlands	--	--	52	135
Netherlands Antilles	36	36	11	24
New Zealand	11	20	--	--
Nicaragua	15	27	--	--
Nigeria	--	--	204	172
Pakistan	45	9	--	--
Panama	33	48	80	158
Peru	65	147	135	140
Philippines	--	--	35	29
Russia	20	37	13	89
Saudi Arabia	194	162	95	262
South Africa	87	80	23	19
Spain	3	3	--	--
Taiwan	2,920	1,210	3,290	1,870
Thailand	124	83	27	22
Trinidad and Tobago	25	35	--	--
Turkey	7	10	7	15
Turks and Caicos Islands	10	17	--	--
United Arab Emirates	446	373	--	--
United Kingdom	25	32	10	13
Venezuela	88	184	79	176
Other	154 r	150 r	99	220
Total	58,600	38,700	49,100	41,000

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Export valuation is free alongside ship.

[3] Less than ½ unit.

Sources: U.S. Census Bureau and U.S. International Trade Commission.

TABLE 16
U.S. IMPORTS FOR CONSUMPTION OF USED RAILS FOR REROLLING AND OTHER USES, BY COUNTRY[1, 2]

	2009		2010	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Austria	--	--	6	$6
Canada	31,300	$7,950	46,800	18,500
China	--	--	16	29
Czech Republic	7	9	--	--
Germany	2	7	15	40
Japan	17	40	4	10
Korea, Republic of	--	--	15	34
Mexico	830	238	107	38
Russia	25,200	9,310	6,250	4,910
Spain	13	116	13	119
United Kingdom	--	--	2	6
Total	57,400	17,700	53,200	23,700

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Import valuation is customs value.

Sources: U.S. Census Bureau and U.S. International Trade Commission.

TABLE 17
U.S. EXPORTS OF DIRECT-REDUCED IRON, BY COUNTRY[1, 2]

	2009		2010	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
China	--	--	213	$31
Costa Rica	--	--	557	59
Indonesia	100	$18	--	--
Mexico	36	6	204	25
Switzerland	58	6	--	--
Uruguay	77	8	--	--
Total	271	38	974	115

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Data are for steelmaking-grade direct-reduced iron only.

Source: U.S. Census Bureau.

TABLE 18
U.S. IMPORTS FOR CONSUMPTION OF DIRECT-REDUCED IRON, BY COUNTRY[1, 2]

	2009		2010	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
South Africa	--	--	39,100	$11,700
Sweden	--	--	63	22
Trinidad and Tobago	807,000	$244,000	1,270,000	490,000
Venezuela	209,000	59,600	331,000	106,000
Total	1,020,000	304,000	1,640,000	607,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Data are for steelmaking-grade direct-reduced iron only.

Source: U.S. Census Bureau.

TABLE 19
U.S. EXPORTS OF PIG IRON, BY COUNTRY[1, 2]

	2009		2010	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Bolivia	1	$4	--	--
Brazil	11	12	9	$9
Canada	5,220	1,890	14,900	7,190
China	361	119	62	19
Colombia	--	--	3,300	25
Dominican Republic	--	--	149	137
France	62	18	--	--
French Polynesia	82	27	--	--
Germany	--	--	25	26
Hong Kong	--	--	37	40
Israel	--	--	29	10
Italy	11	4	--	--
Japan	59	19	2	5
Korea, Republic of	248	244	272	237
Mexico	4,400	1,640	2,200,000	5,530
Netherlands	2	3	--	--
New Zealand	11	4	--	--
Norway	--	--	13	6
Peru	103	34	--	--
Romania	14	15	--	--
Singapore	--	--	113	123
Tunisia	147	157	--	--
United Kingdom	2	6	--	--
Uruguay	--	--	76	25
Total	10,700	4,200	2,220,000	13,400

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes the following grades of pig iron: less than or equal to 0.5% phosphorus content, greater than 0.5% phosphorus content, and alloy grade. Export valuation is free alongside ship value.

Source: U.S. Census Bureau.

TABLE 20

U.S. IMPORTS FOR CONSUMPTION OF PIG IRON, BY COUNTRY[1, 2]

	2009		2010	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Australia	--	--	175	$185
Belgium	--	--	7,000	2,340
Brazil	1,260,000	$478,000	1,600,000	650,000
Canada	90,700	27,300	141,000	63,300
China	--	--	56,900	23,000
Denmark	9	9	--	--
Germany	--	--	37	35
India	6	13	--	--
Italy	4	2	--	--
Russia	751,000	275,000	1,060,000	447,000
South Africa	120,000	37,400	127,000	51,000
Sweden	43,000	12,000	--	--
Ukraine	156,000	47,000	729,000	280,000
Venezuela	--	--	61,300	20,400
Total	2,420,000	877,000	3,780,000	1,540,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes the following grades of pig iron: less than or equal to 0.5% phosphorus content, greater than 0.5% phosphorus content, and alloy grade. Import valuation is customs value.

Source: U.S. Census Bureau.

IRON ORE

By John D. Jorgenson

Domestic survey data and tables were prepared by Michelle B. Blackwell, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

U.S. iron ore production in 2010 increased by 87% compared with that of 2009; consumption during this same period increased by 37%. World iron ore production and consumption rose in 2010 by almost 17%. China, by far the leading consumer, also led gross tonnage production of iron ore with relatively low-grade ore. China was the leading producer of iron ore in terms of iron content, followed by Australia and Brazil (tables 1, 15). For the ninth consecutive year, world iron ore trade increased. World iron ore prices increased significantly compared with those of 2009.

Iron ore is the basic raw material for producing iron and steel. The supply of iron ore is critical to the economies of all industrialized nations. Scrap, a supplement to iron ore in steelmaking, is also an extremely important feed material, but owing to lack of supply of high-quality scrap, its use has limitations. Direct reduced iron (DRI) is an alternative to scrap, but requires iron ore for its production.

Two iron oxides—hematite (Fe_2O_3) and magnetite (Fe_3O_4)—are the primary ore minerals of iron. Taconite, the primary iron ore mined in the United States, contains hematite and magnetite in varying proportions and is found in hard, fine-grained, banded iron formations with iron content between 20% and 30%. Almost all domestic iron ore production is transformed into molten iron in blast furnaces by the iron and steel industry. Most molten iron then goes directly to a basic oxygen furnace (BOF) for conversion to steel by removing most of the residual carbon. The remainder is poured into molds to produce pig iron.

In 2010, the United States used 42.3 million metric tons (Mt) of iron ore, an increase of 11.3 Mt, or 37%, compared with that of 2009, and produced 26.8 Mt of pig iron. Pig iron production increased by more than 40% compared with that of 2009.

Raw steel production, at 80.5 Mt, increased by 36% compared with that of 2009. U.S. steel consumption increased to 80 Mt from 63 Mt in 2009. Imported iron ore supplemented domestically produced iron ore in the production of pig iron, which is used along with imported pig iron, DRI, and scrap to produce raw steel. Integrated steel mills produce steel from iron ore; minimills produce steel from DRI and scrap. In 2010, the minimill sector of the steel industry made up 61% of the U.S. raw steel production (American Iron and Steel Institute, 2011, p. 73).

Integrated steelmakers can increase steel mill product production without increasing blast furnace production by importing pig iron and semifinished steel. This permits steelmakers to avoid costly startup of less-efficient blast furnaces held in reserve and the employment of additional skilled workers. In 2010, net U.S. exports (exports minus imports) of iron ore substitutes were 9.6 Mt, while in 2009 the United States was a net exporter of 14.7 Mt of substitutes. This decrease in net exports was owing to substantial decreases in the levels of scrap steel and semifinished steel products net exports being somewhat offset by an increase in pig iron imports. During the year, along with the 36% increase in raw steel production and a 27% increase in steel demand, iron ore consumption increased 37% from 2009 levels.

Legislation and Government Programs

In 2010, the Minnesota production tax rate to be distributed in 2011 changed for concentrates and pellets produced in 2010, increasing to \$2.380 from \$2.364 per taxable long ton. The taxable tonnage for 2010 was based on the average tonnage produced in 2008–10.

Changes affecting taconite mining and processing operations passed by the Minnesota Legislature in 2010 included a redistribution of the production tax for all 2009 production with distribution in 2010 only. This portion of the production tax established a special fund to receive \$0.28757 per long ton that would otherwise have gone into the Taconite Property Tax Relief Account. The funds from this special account were to be allocated to public works and economic development tax. Another legislative change to tax distributions allowed for transfer of funds from the Taconite Property Tax Relief Account to compensate for any shortfall in funds resulting from levy reductions (Minnesota Department of Revenue, 2010, p. 1, 6, 7, 20; 2011, p. 1, 20).

Production

The U.S. Geological Survey (USGS) develops U.S. iron ore production data through an annual "Iron Ore" survey, which is sent to iron ore mines, and those mines provided the production statistics shown in tables 1 through 4. This information is supplemented by employment data, information from consumers, and mine inspection reports. The American Iron Ore Association became a supplier-oriented organization, now known as the Iron Mining Association of Minnesota, and no longer provides data on ore shipments from loading docks on the Upper Great Lakes nor receipts at transfer docks and furnace yards nationwide. Steel plant data continues to be compiled by the American Iron and Steel Institute (AISI).

In 2010, domestic iron ore production was 49.9 Mt, 87% more than the 2009 production, which was 26.7 Mt. Michigan and Minnesota taconite mines accounted for almost all domestic iron ore production—six mines operated on the Mesabi Range in northeastern Minnesota and two on the Marquette Range in Michigan's Upper Peninsula. Domestic iron ore supply (production minus exports) met 94% of domestic demand in 2010, an increase from 74% for in 2009.

Cliffs Natural Resources Inc. (Cleveland, OH) did not announce 2010 iron ore production for its North American operations on a mine-by-mine basis in its annual report. Mine production totaled 32.5 Mt from the Empire, Hibbing Taconite, Northshore, Tilden, and United Taconite mines in the United States and the Wabush mine in Canada. Cliffs' share of the total production from these North American operations was 25.8 Mt. Total Cliffs' North American production tonnage share for the mines it managed during the year increased by 49% compared with that of 2009, and overall iron ore sales revenue more than doubled compared with that of 2009 to $2.92 billion (Cliffs Natural Resources Inc., 2011b, p. 60).

Michigan.—Michigan accounted for about one-quarter of U.S. usable iron ore output in 2010; nearly all of Michigan's output was pellet production. Production at the Empire and Tilden Mines, mostly magnetite and hematite flux pellets, increased by more than 50% to 12.5 Mt.

Minnesota.—Minnesota produced nearly three-quarters of the usable iron ore in the United States in 2010; nearly all of the output was pellet production. Almost all of the production from the State came from open pits on the Mesabi Iron Range, although a minor amount of the production did come from reworked tailings. Minnesota taxable production, grouped by operating company, was summarized as follows: United States Steel Corp. (Pittsburgh, PA) produced 4.9 Mt of partial flux pellets and a minor amount of fines, chips, and concentrates from its Keewatin Taconite operations and 13.2 Mt of fluxed pellet production from its Minntac operations; Hibbing Taconite Co. produced 5.8 Mt of partial fluxed (containing less than 2% flux) pellets; United Taconite Co., LLC produced 5.0 Mt of partial fluxed pellets, a minor amount of pellet chips and fines, and a minor amount of concentrates; Northshore Mining Co. produced 4.6 Mt of partial fluxed pellets and a small amount of pellet chips and fines; and ArcelorMittal Minorca Mine Inc. (Chicago, IL) produced 2.8 Mt of flux pellets and a minor amount of pellet chips and concentrates (ArcelorMittal, 2011, p. 28; Minnesota Department of Revenue, 2011, p. 21; United States Steel Corp., 2011, p. F–58).

Cliffs completed arbitration for the sales price of blast furnace pellets sold to Essar Steel Algoma, Inc. (Sault Ste. Marie, Ontario, Canada) [a subsidiary of Essar Steel Holdings Ltd. (Mumbai, India)]. The arbitrated redefinition of world prices for blast furnace pellets allowed Cliffs to use an increase greater than 95% compared with 2009 pellet prices in the established pricing formula (Cliffs Natural Resources Inc., 2010a).

Steel Dynamics, Inc. (Fort Wayne, IN) announced the production of the first iron nuggets at its Mesabi Nugget facility in Hoyt Lakes. This was the world's first commercial production of greater than 96% iron nuggets using the ITmk3 process developed by Kobe Steel Ltd. (Kobe, Japan). The plant startup completed 2 years of construction activity and was designed, at anticipated capacity, to produce 500,000 metric tons per year (t/yr) of nuggets, much of which will be feedstock to Steel Dynamics' own electric arc furnaces (EAFs) in Indiana. During the year, Steel Dynamics continued to ramp up operations at its Mesabi Nugget facility. The plant was shut down in November in order to replace refractories in the rotary hearth furnace and for equipment modifications. In 2010, 67,500 metric tons (t) of iron nuggets was produced (Steel Dynamics, Inc., 2010; 2011).

Magnetation, Inc. (Nashwauk) announced the start-up of its new Rev3™ separator, a high-gradient magnetic separator designed to recover high-grade hematite concentrate from fine tailings or to upgrade mined hematite ore. The separator was installed in its Plant 1 near Keewatin. Magnetation planned to install a ball mill and update the Rev3™ separator at the plant by midyear 2011, bringing capacity to 450,000 t/yr. The company also planned to construct a new 650,000-t/yr plant (Plant 2), near Taconite, by the third quarter of 2012.

Magnetation signed a long-term offtake agreement with Altos Hornos de Mexico S.A.B. de C.V. that was planned to start in January 2012. Talks were held with Cargill, Inc. that resulted in an agreement in January 2011, to explore worldwide opportunities to develop and use Magnetation's proprietary mineral processing technology (Magnetation, 2010a, b; Cargill, 2011).

Consumption

U.S. iron ore consumption increased by 37% to 42.3 Mt from 31.0 Mt in 2009 (table 1). Pig iron production, at 26.8 Mt in 2010, was more than 40% greater than the 2009 production of 19.0 Mt. Raw steel production using BOF technology, which had been at the lowest production level in more than a decade in 2009, increased by 38% to 31.2 Mt.

Consumption of iron ore, including agglomerates, reported to the AISI by producers of iron and steel totaled 41.7 Mt, including 36.0 Mt of pellets; 5.2 Mt of sinter, briquettes, and other products; and 0.4 Mt of natural coarse ore (table 6). Of the ore consumed, 85% was domestic production; 10%, imports from Canada; and 5%, imports from other countries. Other iron-bearing materials charged to blast furnaces included mill scale, slag scrap, and steel furnace slag.

The three consumption numbers used in this annual review are reported in tables 1, 6, and 7. The first consumption number (42.3 Mt in 2010), in table 1, is the sum of the ore consumed by input type reported by the AISI, the ore consumed in DRI production, and the ore consumed in nonsteel uses, as reported to the USGS (American Iron and Steel Institute, 2011, p. 81). The second consumption number (41.7 Mt in 2010), in table 6, is the ore consumed in U.S. iron and steel plants by type of ore reported by the AISI. The third consumption number is an estimate of DRI and other miscellaneous uses, which include iron ore consumed in production of cement and iron ore shipped for use in manufacturing paint, ferrites, heavy media, cattle feed, refractory and weighing materials, and for use in lead smelting are listed in table 7. The latter consumption figure was the ore consumed in DRI production (of which there was none produced in 2010) and nonsteel uses (0.62 Mt in 2010). Data on iron ore consumption in nonsteel end uses (table 7) were compiled from USGS surveys and information provided by Midrex Technologies, Inc. (2011, p. 7).

Prices

Iron ore negotiations for 2010–11 benchmark prices between Chinese steelmakers and Australian producers BHP Billiton Ltd. (Melbourne, Australia) and Rio Tinto plc (London, United Kingdom) began early in 2010. Talks were held in Singapore owing to legal problems that developed the previous year for Rio Tinto's negotiators in China. Analysts expected ore prices to rise between 10% and 50% from those of the prior year with producers expected to hold back until Japan and the Republic of Korea had signed deals. Anticipation of the Indian Government introducing export duties on iron ore and a subsequent rise in spot iron ore prices from Indian iron ore exporters were expected to push the contract benchmark price higher for the 2010 contract. The Brazilian Government's discussion of a possible iron ore export tax to stimulate the domestic steel industry was also seen as supporting an increase in contract prices (Cavallaro, 2010; Metal Bulletin, 2010b, c).

Vale S.A. (Rio de Janeiro, Brazil) and BHP Billiton reached agreement with major steelmakers from China, Japan, and the Republic of Korea to accept quarterly ore repricing. In 2010, prices were almost two times those of the 2009 contract year (Jenkins, 2010).

April 2010 represented the end of the 40-year global benchmarking system for the sale of iron ore under an annual contract. Iron ore producers felt they had been losing out, with contract prices regularly falling below the spot market price and with some customers reneging on contract tonnages when spot price fell below the contract price. BHP Billiton and Vale reached agreements with several customers to move to shorter-term or quarterly contracts. Rio Tinto had not reached agreements but was looking toward annual supply agreements with quarterly price adjustments. As a result of the end of the benchmarking system, publication of contract prices in Japan, listed in table 16 in previous Minerals Yearbook chapters, have been discontinued.

China reported that the change to quarterly negotiated prices would lead to continued price increases, short-run profits for iron ore suppliers, and reduced profit margins for Chinese steel mills. China placed a ban on imports of ore with less than 60% iron content—a move that should favor the big three producers (BHP Billiton, Rio Tinto, and Vale), while hampering imports of lower grade ores from India. Additionally, the China Chamber of Commerce of Metals Minerals & Chemical Importers & Exporters and the Chinese Iron and Steel Association (CISA) agreed to revoke import licenses for small traders and to restrict reselling of imported iron ore. According to Chinese sources, calls for boycotting Australian iron ore imports into China by CISA led to retaliatory export cutbacks by the big three producers. The ban on low-grade iron ore imports by China prompted a crackdown on illegal mines in India's Orissa State, thereby limiting exports of this ore to China (Karpel, 2010; Rosenquist, 2010).

By May, CISA and ArcelorMittal confirmed the end to the benchmarking system, and many steelmakers indicated that an iron ore surcharge on steel sales might result. BHP Billiton, Rio Tinto, and Vale settled annual iron ore contracts with a quarterly pricing mechanism. Vale indicated it would allow customers to select an index to use as the basis of a pricing formula. BHP and Rio Tinto did not reveal its pricing formula but indicated that quarterly prices would be based on indices from the previous quarter. In midyear, Rio Tinto changed the reference period for calculating its quarterly iron ore prices. Rio Tinto's new pricing mechanism was then more in line with that of Vale (Antonioli, 2010; Metal Bulletin, 2010e, g).

Wuhan Iron and Steel Co. Ltd. (WISCO), China's third-leading steelmaker, secured a special price from Corporación Venezolana de Guayana (CVG) at about $20 per metric ton below the third quarter price being charged by Vale to its Asian customers. CVG, a Venezuelan state-owned mining and metallurgical group, sold 480,000 t of iron ore in 2009 to WISCO and had an existing contract to sell WISCO more than 40 Mt of iron ore during the next 7 years (Skillings Mining Review, 2010b).

ThyssenKrupp Steel Europe responded to the new quarterly iron ore pricing mechanism by introducing a surcharge on annual steel contracts. Other European steelmakers were expected to follow suit in order to transfer their pricing risk to the customer. Upward movement of iron ore prices was expected to increase pricing risk in the short- to medium-term owing to cancellation or deferral of major iron ore mining projects caused by the economic downturn that began in late 2008 (Gleeson, 2010; Hodge, 2010).

Later in the year, supplies of contract iron ore exported to small Chinese mills reportedly were cut by BHP Billiton, Rio Tinto, and Vale. Larger Chinese mills were expected to adopt contract prices developed by Japanese and Korean mills, while smaller Chinese mills awaited a negotiated price (Metal Bulletin, 2010d).

Transportation

The Lake Carriers' Association reported that the iron ore shipments on the Great Lakes rebounded after having fallen to the lowest level in 71 years in 2009. Iron ore cargos on the Great Lakes totaled 43.7 Mt, an increase of 68% compared with those of 2009. Iron ore shipments for 2010 were slightly below the 5-year average of 2005–09. The locks at Sault Ste. Marie, MI, opened 4 days ahead of schedule, on March 21, owing to the increased need for iron ore from steel plants located on the Lower Lakes (Lake Carriers' Association, 2010; 2011).

Foreign Trade

In 2010, U.S. exports of iron ore exceeded imports by 55%, which represented only a minor percentage of domestic apparent consumption. Exports increased by more than 150%, while imports increased by two-thirds compared with 2009 figures. U.S. iron ore exports were 93% pellets (9.2 Mt), and 81% of the exports was shipped via the Great Lakes to Canadian steel companies, while 7% was shipped to China, 3% to Germany, 2% each to France and Mexico, and the rest to 13 other countries. U.S. imports totaled 6.4 Mt, of which Brazil's share increased to 8% from 5% in 2009, Canada's share decreased to 70% from 81% in 2009, and Russia's share increased to 9% from 4% in 2009 (tables 1, 8–14).

World Industry Structure

Consumption.—Although not a direct measure, imports of iron ore and production of crude steel, DRI, and pig iron can be used as guides to indicate whether global iron ore consumption rises or falls. DRI and pig iron production are likely to be more direct indicators of iron ore consumption than crude steel production because, to varying degrees in each country, part of steel production comes from scrap consumption in minimills. Iron ore net imports cannot be used as a straightforward indicator of a change in iron ore consumption in countries that produce iron ore unless a country's own ore production remains constant. World consumption of iron ore was estimated to have increased as indicated by increases in pig iron (12%) and DRI (5%) production compared with 2009 levels. Of the nine countries that accounted for 2% or more of world pig iron production in 2010, four of the countries showed negative growth, including the United States, comparing 2010 production with each country's average pig iron production from 2006 through 2010. The growth rates compared with the 5-year average (2006–10) for these countries were as follows: India, 22%; China, 18%; the Republic of Korea, 6%; Germany, 3%; Japan, 1%; Russia, 0.6%; Ukraine, 8%; the United States, 13%; and Brazil, 18%. Whereas in 2009, only two (China and India) of the five leading producing countries of pig iron showed an increase in pig iron production compared with that of 2008, all countries showed an increase in production in 2010 compared with that of previous year—China, 7%; India, 14%; Japan, 23%; the Republic of Korea, 14%; and Russia, 11%.

Interest in mine development continued to increase in 2010 owing to a recovery from the global economic downturn that began in 2008, as producers positioned themselves to take advantage of expected continuing high levels of consumption driven by Chinese economic growth. With new iron ore production capacity becoming available through existing producers, world supply of iron ore was expected to be adequate at least through 2013. A potential large increment of iron ore supply may come into the market in 2015 and beyond from new producers in West Africa and Brazil (Gray, 2011, p. 20–21).

World crude steel production increased to 1.4 billion metric tons (Gt) from 1.2 Gt in 2009. Seven countries produced more than 35 Mt of crude steel each and combined accounted for almost 75% of world production in 2010. Of those countries, China produced about 53 Mt more crude steel in 2010 than in 2009 and the United States and Japan each produced 22 Mt more. Combined production from the others (Germany, India, the Republic of Korea, and Russia) was 33 Mt more in 2010 than in 2009. Annual world crude steel production, excluding China, increased by more than 130 Mt in 2010. Between 2001 and 2010, China, Germany, India, Japan, the Republic of Korea, Russia, and the United States accounted for more than two-thirds of combined world crude steel production. China's 2010 production was almost 65% greater than its average for the 10-year period, while that of the United States was 10% less than its average for the 10-year period (United Nations Conference on Trade and Development, 2011, p. 124–126).

Production.—World iron ore production of 2.6 Gt, gross weight, increased by 17% from 2009 production levels. Annual world production has exceeded 1 Gt, gross weight, each year since it first reached that level in 1995, and has exceeded 2 Gt since 2007. Australia's and Brazil's combined share of world production by gross weight from 2006 through 2010 averaged 32%. In 2010, iron ore was produced in 41 countries, with production exceeding 1 Mt, gross weight, in 27 of those countries. World DRI production increased to 70.4 Mt, which was 9% greater than that of 2009 (Midrex Technologies, Inc., 2011).

Trade.—World iron ore imports of 1.05 Gt rose by 12% compared with 2009 levels. Following large year-on-year increases in imports for the past 8 years (21% in 2002, 33% in 2003, 40% in 2004, 32% in 2005, 19% in 2006, 17% in 2007, 16% in 2008, and 42% in 2009), China posted a slight decline in iron ore imports to 619 Mt in 2010 from 630 Mt in 2009. Since 2001, four countries, China, Germany, Japan, and the Republic of Korea, have accounted for more than two-thirds of world iron ore imports. China's share more than tripled during this 10-year period to 59% from 19%. Germany's share of imports in that period decreased to 4% from 8%, Japan's share decreased to 13% from 26%, and the Republic of Korea's share decreased to 5% from 9%.

World iron ore exports of 1.07 Gt increased by 11% compared with 2009 levels. Australia's and Brazil's combined share of world iron ore exports increased slightly to 67% in 2010 compared with their revised share in 2009. Five countries accounted for more than 83% of world iron ore exports. In decreasing order of market share, Australia held 38%; Brazil, 28%; India, 9%; South Africa, 5%; and Canada, 3% (United Nations Conference on Trade and Development, 2011, p. 107–110).

According to The TEX Report (2011a–c), China, the world's leading importer of iron ore, imported 619 Mt of iron ore in 2010. The leading exporters of nonagglomerated ore to China were South Africa (56%), Australia (43%), Brazil (21%), India (16%), and Iran (2%), with the remainder shared among more than 30 countries. Russian iron ore exports to China in 2010 decreased by 27% compared with those of 2009, while those to the United States increased fourfold during the same period. The European Union (EU) increased iron ore imports in 2010 by 48% compared with those of the previous year.

Mergers and Acquisitions.—ArcelorMittal and BHP Billiton discussed the possibility of combining iron ore assets in Liberia and Guinea, but later announced that these discussions had been terminated. The discussions included BHP Billiton's 41.3% share of the Nimba project and exploration leases in Guinea, as well as four leases in Liberia. The merger of assets would have included ArcelorMittal's five Liberian leases and rights to upgrade an existing railway and Panamax port (BHP Billiton Ltd., 2010a; Hotter, 2010).

Cliffs completed the acquisition of Wabush Mines from the two other joint-venture partners—U.S. Steel Canada (Hamilton, Ontario, Canada) (a subsidiary of U.S. Steel) and ArcelorMittal Dofasco (Hamilton, Ontario, Canada) (a subsidiary of ArcelorMittal). The Wabush Mines acquisition included mine, rail, concentrating, pelletizing, and port operations in Newfoundland and Labrador, and Quebec Provinces, Canada. The $88-million purchase increased Cliffs' ownership in the operations to 100% from 26.8%. Wabush Mines has a production capacity of 5.6 million metric tons per year (Mt/yr) and about 70 Mt of iron ore reserves (Cliffs Natural Resources Inc., 2009; 2010b).

Mitsubishi Corp. (Tokyo, Japan) acquired 25% of the shares in Compañía Minera del Pacífico (CMP) S.A. [the mining subsidiary of Compañía de Acero del Pacífico S.A. (Santiago, Chile)]. Mitsubishi funded a $400 million capital increase for CMP for a total acquisition cost of $924 million. CMP has several Chilean iron ore mines, plants, and ancillary facilities, as well as mineral rights to several iron ore deposits in Chile (Gardner, 2010).

In April, some analysts expressed the opinion that the proposed merger of BHP Billiton and Rio Tinto appeared to be unlikely. Problems with competition commissions in Australia, China, and the EU hampered proceedings. A reevaluation of the equalization payment to Rio Tinto for the merger indicated that payments may be undervalued. There was a $275 million penalty to either party if they cancelled the agreement, did not recommend the transaction to shareholders, or did not uphold exclusivity provisions of the agreement. In October, BHP Billiton and Rio Tinto agreed to dissolve the proposed joint venture of their Western Australian iron ore assets (BHP Billiton Ltd., 2010b; Tredway, 2010a).

In August, Xstrata Plc (Zug, Switzerland) made a $383 million offer for all the shares in Sphere Minerals Ltd. (West Perth, Australia). Sphere Minerals owned three iron ore properties in Mauritania—Guelb el Aouj (joint venture with the State-owned producer), Askaf, and Lebtheinia. Sphere Minerals had planned to develop the Askaf deposit in stages—2 Mt/yr beginning in 2012 and ramping up to 6 Mt/yr in 2016 (Tredway, 2010b).

World Review

Afghanistan.—The Government of Afghanistan decided to rebid the 1.8-Gt Hajigak iron ore deposit about 100 kilometers (km) west of Kabul. Rumors about the initial bid concerning lack of transparency, low interest, and the exclusion of a downstream integrated steelmaking facility option were all factors in the decision to rebid the project (Skillings Mining Review, 2010a).

Australia.—Development of iron ore and other mineral reserves reportedly may have been threatened by imposition of a resources super-profits tax. BHP Billiton estimated that such a 40% federal tax would increase its overall tax burden to 57% from 43%. Several companies indicated that such a tax increase would cause them to cancel projects or move investments overseas. BHP Billiton, Fortescue Metals Group Ltd. (East Perth, Australia), and Rio Tinto placed Australian projects on hold to evaluate the effects of the new taxes on project economics (Creagh, 2010; Metal Bulletin, 2010f).

BHP Billiton announced full-year production figures for 2010. BHP Billiton's share of salable quantities of iron ore (wet) were as follows (Australia, unless otherwise specified)—Area C Joint Venture (JV) (85% owned), 39.5 Mt; Goldsworthy JV (85% owned), 1.5 Mt; Mount Newman JV and Jimblebar (85% owned), 37.2 Mt; Samarco (Brazil) (50% owned), 11.7 Mt; and Yandi JV (85% owned), 38.2 Mt. BHP Billiton's share of total world mine production was 128 Mt, a 9% increase from that of 2009 (BHP Billiton Ltd., 2010c, p. 4; 2011a, p. 4).

BHP Billiton continued work on its Rapid Growth Project 5 (RPG5) which would facilitate ongoing development of port, rail, and Jimblebar Mine infrastructure. RPG 5, a $4.80 billion project with engineering 99% complete and construction 89% complete by yearend 2010, was expected to add 50 Mt/yr to system capacity by the second half of 2011 (BHP Billiton Ltd., 2011b).

Rio Tinto announced full-year production figures for 2010. Rio Tinto's share of salable quantities of iron ore plus pellets were as follows (Australia, unless otherwise specified)—Channar (60% owned), 6.6 Mt; Eastern Range, 9.2 Mt; Hamersley, 112.7 Mt; Hope Downs (50% owned), 15.9 Mt; Iron Ore Co. of Canada (IOC) (Canada; 58.7% owned), 8.6 Mt; and Robe River (53% owned), 31.6 Mt. Rio Tinto's share of total world mine production was 184.6 Mt, an 8% increase from that of 2009 (Rio Tinto plc, 2011).

Rio Tinto's Pilbara region iron ore production reported a substantial increase mainly resulting from the 2010 startup of the Mesa A/Warramboo Mine. Rio Tinto approved $200 million in funding to prepare for the expansion of its iron ore operations in Western Australia. The initial funding was for dredging contracts to establish an additional 1.8 km, four-berth jetty and wharf at Cape Lambert as part of its overall plan. The broader plan included the expansion of the mines in the Pilbara and development of additional port capacity at Dampier and Cape Lambert in order to expand iron ore operating capacity to 330 Mt/yr by 2016 (Rio Tinto plc, 2010a, p. 2, 9).

After losing a court case, Fortescue Metals agreed to pay Zodiac Maritime Agencies Ltd. (London, United Kingdom) $78 million for suspending a charter contract for the transport of iron ore in 2008. This attempt to lock in shipping rates for its Western Australian iron ore at much lower levels than originally contracted brought Fortescue's total damage payments to shipping companies to $151 million (Mining Journal, 2010a).

The Australian Competition Tribunal ruled on June 30 that third-party access to Rio Tinto's Hamersley and BHP Billiton's Newman rail lines was not in the public interest (Australian Journal of Mining, 2010).

China's Sinosteel Midwest Corp. and the Karara joint venture between China's Anshan Iron and Steel Group and Australia's Gindalbie Metals Ltd. (Perth) agreed to share infrastructure and mine services. The sharing of facilities was expected to enhance project economics and develop synergies between the Karara iron ore project and Sinosteel's Koolanooka/Blue Hills project in Western Australia. Sinosteel expected to begin operation of a 1.5-Mt/yr hematite mine before the end of February. The Ansteel-Gindalbie joint venture expected to begin production at Karara in 2011 (Mining Journal, 2010c).

Brazil.—A strong rebound from the low levels of production of iron ore and pellets in 2009 was reported by Brazil's Vale. In 2010, Vale's reported iron ore production was 307.8 Mt (includes Vale's 50%-joint venture in Samarco)—an increase of 29% compared with that of 2009. Vale's share of salable quantities of iron ore was as follows, in decreasing order of tonnage—Southeastern System, 116.9 Mt; Carajás, 101.2 Mt; Southern System, 74.7 Mt; Samarco, 10.8 Mt; and the newly created Midwestern System (comprised of Corumbá and Urucum), 4.2 Mt. Vale pellet production in 2010 was 49.0 Mt (includes Vale's 50%-joint venture in Samarco and Vale's 50.89% ownership in Hispanobras)—more than doubling the company's pellet production of 2009. The breakdown of salable quantities of iron ore pellets was as follows, in decreasing order of pellet production—Samarco, 10.8 Mt; Nibrasco, 9.0 Mt; Tubarão I and II, 5.4 Mt; Vargem Grande, 5.2 Mt; Kobrasco, 4.7 Mt; São Luís, 4.5 Mt; Fábrica, 3.8 Mt; Itabrasco, 3.6 Mt; and Hispanobras, 1.9 Mt (Vale S.A., 2011, p. 2–3).

MMX Mineração e Metálicos S.A. (Rio de Janeiro) announced plans to invest $2.9 billion to increase iron ore production at its Serra Azul and Bom Sucesso Mines in southeastern Minas Gerais State. The planned increases would significantly lower production costs at the Serra Azul Mine (Millard, 2010).

Canada.—IOC [owned jointly by Labrador Iron Ore Royalty Income Fund (15.1%), Mitsubishi Corp. (26.18%), and Rio Tinto (58.72%)] produced 2.8 Mt of iron ore concentrates and 11.9 Mt of iron ore pellets. ArcelorMittal Mines Canada (formerly Québec Cartier Mining Co.) produced 15.1 Mt of iron ore concentrates and pellets. Wabush Mines Ltd. (owned by Cliffs as of December 31, 2010), which no longer publicly reports production by individual mining entities, had produced 2.7 Mt of iron ore pellets in 2010; Bloom Lake Partnership [owned 75% by Consolidated Thompson Iron Mines Ltd. (Montreal, Quebec) and 25% by WISCO Ltd. (a wholly owned subsidiary of WISCO)] produced 3.0 Mt of iron ore (ArcelorMittal, 2011, p. 30; Cliffs Natural Resources Inc., 2011a, p. 7; Labrador Iron Ore Royalty Corporation, 2011, p. 4).

The board of directors of IOC approved a new investment of $400 million to increase annual iron ore concentrate capacity in 2012 to 22 Mt from 18 Mt. The original project expansion was canceled in 2008 owing to the global economic downturn. The revised total project cost for the IOC first stage expansion was $497 million, of which some costs had been spent prior to the earlier suspension of the project (Rio Tinto plc, 2010b). IOC's overall production was affected by the increased pellet to concentrate ratio during the second quarter. The lower total tonnage produced resulted from the weight loss in transforming concentrate to higher value pellets (Rio Tinto plc, 2010d, p. 3).

Consolidated Thompson shipped its first iron ore concentrate—165,000 t, to WISCO in China—from its Bloom Lake Mine in northeastern Quebec. The shipment was made from Consolidated Thompson's new port facilities at Pointe Noire in Sept Iles, Quebec. Consolidated Thompson planned to ship 8 Mt/yr from the mine, which has the potential to expand to 16 Mt/yr capacity. Consolidated Thompson entered into an offtake agreement with a subsidiary of SK Group (Seoul, Republic of Korea) to purchase 1 Mt/yr of iron ore concentrates for a 10-year period (Consolidated Thompson Iron Mines Ltd., 2010a, b).

Labrador Iron Mines (LIM) Holdings Ltd. (Toronto, Ontario) announced that construction on the James iron ore mine in the Province of Quebec was nearly complete. Mine production was scheduled to begin in April 2011 and more than 2 Mt of direct-shipping ore was expected to be mined in 2011. LIM expected plant construction to be completed during the first quarter of 2011 (Labrador Iron Mines Holdings Ltd., 2010).

Guinea.—Rio Tinto signed a memorandum of understanding with Aluminum Corporation of China Ltd. (Beijing, China) (Chinalco) that would establish a joint venture to develop and operate the Simandou iron ore project (Simandou blocks 3 and 4). With an investment of $1.35 billion, Chinalco would obtain a 44.65% interest in the project (Rio Tinto plc, 2010a, p. 2–3). In late July, Rio Tinto signed a binding agreement with Chinalco to establish a joint venture to develop and operate the project. The mine was expected to begin operation within 5 years and was expected to produce 95 Mt/yr at full capacity. In early August, Rio Tinto approved $170 million in further funding for the Simandou iron ore project. Funding was for mine, rail, and port infrastructure work and was additional to the $650 million already spent on exploration, community development, and evaluation studies (Rio Tinto plc, 2010c).

Vale acquired a majority stake in its own Simandou iron ore project (Simandou blocks 1 and 2) in Guinea for an estimated $2.5 billion. Vale acquired 51% of BSG Resources Ltd. (St. Peter Port, United Kingdom), which holds iron ore concessions in the Simandou Sul region (Fick, 2010). Vale entered into an agreement with the Liberian Government to develop infrastructure for the transport and export of iron ore from its Simandou project in Guinea (note that this project is different from Rio Tinto's Simandou project in Guinea). Vale planned to establish a 50-Mt/yr iron ore mine at Simandou by 2014, with production planned to begin between 10 Mt/yr and 15 Mt/yr in 2012. The estimated cost for the project was more than $5 billion (Metal Bulletin, 2010h).

Iran.—Annual iron ore and iron ore concentrate exports were increased by 270% compared with those of fiscal year 2009. In the fiscal year ending April 20, 2010, its exports of iron ore and concentrates were 1.19 Mt, of which more than 97% was delivered to China (Metal Bulletin, 2010i).

Liberia.—ArcelorMittal restarted a planned $1.5 billion iron ore mine startup that had been delayed since 2009 owing to the downturn of the global economy. ArcelorMittal planned to make its first iron ore shipment from the Nimba Mine in 2011; construction and development work started during 2010 (Reuters, 2010).

Oman.—Vale agreed to sell 30% of Vale Oman Pelletizing Company LLC (VOPC) to Oman Oil Company S.A.O.C., which is wholly owned by the Government of Oman. The VOPC pelletizing plant was scheduled to begin production in 2011 with a production capacity of 9 Mt/yr of direct reduction pellets (Vale S.A., 2010; 2011).

Saudi Arabia.—London Mining plc (London, United Kingdom) released an updated feasibility study for the Wadi Sawawin iron ore project in northwest Saudi Arabia. London Mining estimated that capital expenditures for the 5-Mt/yr project would total $2 billion, which would include power and desalinization plants. Operating costs were estimated to be $47.4 per metric ton of DRI pellets produced. The project was a 50–50 joint venture between London Mining and Saudi-based National Mining Co. Further feasibility work was planned to raise the resource estimate and to increase annual capacity to 10 Mt/yr of DRI pellets (Mining Journal, 2010b).

South Africa.—After announcing plans to increase the price of iron ore sold to ArcelorMittal South Africa Ltd. (Amsa), Kumba Iron Ore Ltd. (Pretoria, South Africa) (a subsidiary of Anglo American plc) conceded to an interim iron ore pricing agreement with prices, $70 per ton for the Amsa inland steel mills and $50 per ton for Amsa's Saldanha steel facility, remaining unchanged into 2012. It appeared that Amsa, which controlled 70% to 80% of South Africa's domestic steel industry, was able to obtain the agreement by warning that it might close its Saldanha steel plant, 40 km north of Cape Town. Amsa lost control of a 21.4% stake in minerals rights to the Sishen iron ore mine earlier in 2010 when it failed to convert its mineral rights to the mine (Metal Bulletin, 2010a; Anglo American plc, 2011).

Sweden.—Luossavaara-Kiirunavaara Aktiebolag's (LKAB) (Luleå) iron ore pellet production increased to 22.1 Mt from 14.7 Mt in 2009. Pellet production was most of the total, although 3.2 Mt of fines and minor special products were produced, a slight increase in production of this material from 3.0 Mt in 2009. LKAB announced Kiruna's proven ore reserves to be 579 Mt at 48.7% iron content, and probable ore reserves of an additional 79 Mt at 46.2% iron content. The company reported Malmberget's proven ore reserves to be 270 Mt at 42.5% iron content, and reserves at the newly opened Gruvberget Mine to be 10 Mt at 53.2% iron content. LKAB announced plans for three new open pit mines in the Svappavaara area and new strategy to increase mine production to 37 Mt/yr within 5 years (Luossavaara-Kiirunavaara Aktiebolag, 2011, p. 5–6, 19).

Outlook

Although a small portion of the production recovery for U.S. iron ore has been inventory building, iron ore production has returned to tonnages seen before the 2008–09 economic downturn, and steel production also has been recovering from the downturn. Most U.S. iron ore production is sold directly to the domestic steel industry, although a large amount of domestic ore is shipped to Canada, and small amounts are generally exported to other countries. Neither the domestic dependence nor the pattern of exports to Canada is expected to change in the near future, although changes in ownership of some steel plants have led to minor changes in the countries from which iron ore is imported. For example, with the sale by Severstal of the Sparrow's Point (Baltimore, MD) steel plant, it is expected that iron ore imports currently received from Russia and the Ukraine will be sourced either from Brazil or Canada.

Trends in the steel industry are provided in the "Outlook" section in the Iron and Steel chapter of the 2010 USGS Minerals Yearbook, volume I, Metals and Minerals. The development of projects, using new and existing direct reduction technology being developed in northern Minnesota, was expected to encourage growth of the U.S. iron ore industry within the next few years, as developments such as Steel Dynamics' Mesabi Nugget project comes to full production and Essar Steel's Minnesota Iron project is built.

China's gross domestic product is expected to maintain a greater than 8% annual growth rate through 2015 with significant growth potential in the intensity of steel use in the interior regions of the country (Brooks, 2011, p. 9–10). It is expected that rising exports from other countries will displace some of the high cost Chinese ore exports through 2015, with pellet and lump ore gaining market share with respect to sinter fines. Brazil's MMX is an example of one of the many smaller companies planning to take advantage of growth potential with plans to increase production fourfold during the next 5 years (Bou-Habib, 2011, p. 5–7, 33). Larger companies and entire regions have plans in place to also take advantage of this potential growth for the next several years. Brazil's Vale anticipates doubling its 2010 production of run-of-mine iron ore by 2017, and projections for Canada's iron ore production indicate that iron ore production in that country may double by 2014 (Palmiere, 2011, p. 5; Valadao, 2011, p. 5).

With the collapse of iron ore benchmark prices in 2010, two pricing mechanisms are developing—an iron ore index, such as IODEX, and a historic basis, such as the previous quarter minus 1 month (3-month basis). The historic basis, which averages prices for a 3-month period, does not reflect actual pricing during short time periods when there is high price volatility. Index prices are now being considered that will extend iron differential pricing to all grades, lump, and pellets; establish alumina and silicon differentials; and use formulas to model price escalators (Browne, 2011, p. 19).

New developments in DRI technology, as well as growth in the DRI market share, would allow the iron ore industry to become a major supplier to an expanding DRI sector, as well as to existing customers—the integrated steel plants. Coastal U.S. steel producers already rely on imported DRI to supply a quality raw-material input to help meet steel alloy purity specifications, which cannot be obtained solely using traditional scrap. However, even in the event of strong global DRI growth during the next decade, DRI would be able to replace only a small portion of the world's blast furnace production. Although no new "greenfield" pig iron facilities have been built in the United States in the past 30 years, and owing in part to the continued slow growth in the DRI market, the blast furnace, with its need for an assured supply of iron ore, is expected to remain the mainstay of the iron and steel industry in the immediate future.

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TABLE 1
SALIENT IRON ORE STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2006	2007	2008	2009	2010
United States, iron ore, usable, less than 5% manganese:[2]						
Production		52,700	52,500	53,600	26,700	49,900
Shipments:						
Quantity		52,700	50,900	53,600	27,600	50,600
Value		2,840,000	3,040,000	3,770,000	2,560,000	5,000,000
Average value at mines	dollars per metric ton	53.88	59.64	70.43	92.76	98.79
Exports:						
Quantity		8,270	9,310	11,100	3,920	9,950
Value		636,000	718,000	1,240,000	356,000	1,090,000
Imports for consumption:						
Quantity		11,500	9,400	9,250	3,870	6,420
Value		611,000	543,000	918,000	376,000	703,000
Consumption, iron ore and agglomerates		58,200	54,700	51,900	31,000	42,300
Stocks, December 31, at mines, plants and loading docks		1,650	2,090	4,070	5,060	3,470
Additional stocks, December 31:						
Crude ore at mines and plants[4]		1,140	749	947	580	734
Unagglomerated concentrates for pelletizing plants		1,260	1,550	1,320	896	949
World, production[5]		1,830,000 r	2,040,000	2,210,000	2,230,000 r	2,590,000 e

e Estimated. r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Direct-shipping ore, concentrates, agglomerates, and byproduct ore.

[3] Excludes byproduct ore.

[4] Crude ore stocks and unagglomerated concentrates for pelletizing plants removed. Marketable stocks only.

[5] Gross weight.

TABLE 2
EMPLOYMENT AT IRON ORE MINES AND BENEFICIATING PLANTS, QUANTITY AND TENOR OF ORE PRODUCED, AND AVERAGE OUTPUT PER WORKER HOUR IN THE UNITED STATES IN 2010, BY DISTRICT AND STATE[1]

				Production				Average quantity per worker hour (metric tons)		
District and State	Number of mines	Average number of employees	Worker hours (thousands)	Crude ore (thousand metric tons)	Usable ore (thousand metric tons)	Iron contained in usable ore (thousand metric tons)	Iron content natural (percent)	Crude ore	Usable ore	Iron contained
Lake Superior:										
Michigan[2]	2	1,340	3,080	37,600	12,500	7,570	60.5	12.20	4.06	2.46
Minnesota	7	3,380	7,010	128,000	37,400	23,700	63.4	18.21	5.33	3.38
Total or average	9	4,720	10,100	165,000	49,900	31,300	62.7	16.38	4.94	3.10
Other States[3]	4	58	123	12	12	7	54.0	0.10	0.10	0.05
Grand total or average	13	4,780	10,200	165,000	49,900	31,300	62.7	16.18	4.89	3.06

[1] Data are rounded to no more than three significant digits, except "Average per worker hour, crude ore" may not add to totals shown.

[2] Does not include professional or clerical workers at mines, pelletizing plants, maintenance shops, or research lab workers.

[3] Includes California and South Dakota.

TABLE 3

USABLE IRON ORE PRODUCED IN THE UNITED STATES IN 2010, BY DISTRICT, STATE, AND TYPE OF PRODUCT [1, 2]

(Thousand metric tons)

District and State	Direct shipping ore	Concentrates	Sinter	Other agglomerates[3]	Total
Lake Superior:					
Michigan	--	--	--	12,500	12,500
Minnesota	--	310	79	37,000	37,400
Total	--	310	79	49,500	49,900
Other States[4]	--	12	--	--	12
Grand total	--	322	79	49,500	49,900

-- Zero.

[1] Excludes ore containing 5% or more manganese.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Data may include pellet chips, screenings, and sinter.

[4] Includes California and South Dakota.

TABLE 4

SHIPMENTS OF USABLE IRON ORE FROM MINES IN THE UNITED STATES IN 2010[1, 2]

	Gross weight of ore shipped (thousand metric tons)					Average iron content, natural	
District and State	Direct shipping ore	Concentrates	Sinter	Other agglomerates	Total	(percent)	Value (thousands)
Lake Superior:							
Michigan	--	--	--	11,900	11,900	60.5	W
Minnesota	--	310	75	38,400	38,800	63.4	W
Total reportable or average	--	310	75	50,200	50,600	62.7	$5,000,000
Other States[3]	--	12	--	--	12	54.0	584
Grand total or average	--	322	75	50,200	50,600	62.7	5,000,000

W Withheld to avoid disclosing company proprietary data; included in "Total reportable or average." -- Zero.

[1] Includes byproduct ore. Excludes ore containing 5% or more manganese.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Includes California and South Dakota.

TABLE 5
IRON ORE-PRODUCING MINES IN THE UNITED STATES IN 2010

State and mine	County	Operator	Source of iron ore
California:			
Baxter Mine	San Bernardino	Hahm International Inc.	Quarried ore.
Dredge 21	Yuba	Cal Sierra Development Inc.	Dredged sands.
Silverlake Mine	San Bernardino	Hahm International Inc.	Quarried ore.
Michigan:			
Empire	Marquette	Cliffs Natural Resources Inc.	Magnetite taconite ore.
Tilden	do.	do.	Hematite-magnetite taconite ore.
Minnesota:			
Hibbing Taconite	Saint Louis	do.	Magnetite taconite ore.
Keewatin Taconite	do.	United States Steel Corporation	Do.
Mesabi Chief Plant	do.	Magnetation, Inc.	Hematite tailings.
Minntac	do.	United States Steel Corporation	Magnetite taconite ore.
Minorca	do.	ArcelorMittal	Do.
Northshore	do.	Cliffs Natural Resources Inc.	Do.
United Taconite	do.	do.	Do.
South Dakota, CF & I Pit	Lawrence	Pete Lien & Sons Inc.	Quarried ore.

Do., do. Ditto.

TABLE 6
CONSUMPTION OF IRON ORE AT U.S. IRON AND STEEL PLANTS, BY TYPE OF PRODUCT[1]

(Thousand metric tons)

Type of product	2009	2010
Blast furnaces:		
Direct-shipping ore	--	--
Pellets	26,200	36,000
Sinter[2]	3,720	5,090
Total	29,900	41,100
Steelmaking furnaces:		
Direct-shipping ore	327	408
Sinter[2]	91	136
Total	417	544
Grand total	30,300 r	41,700

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes briquettes, nodules, and other.

Source: American Iron and Steel Institute.

TABLE 7
U.S. CONSUMPTION OF IRON ORE FOR DIRECT-REDUCED IRON AND NONSTEEL END USES[1, 2]

(Thousand metric tons)

Year	Direct–reduced iron for steelmaking[3]	Nonsteel end uses[4]	Total
2006	360	867	1,230
2007	375	699	1,070
2008	390	734	1,120
2009	--	603	603
2010	--	616	616

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes agglomerates. Excludes ore containing 5% or more manganese.

[3] U.S. Geological Survey estimates based on production reports compiled by Midrex Corp.

[4] An estimate, which includes iron ore consumed in production of cement and iron ore shipped for use in manufacturing paint, ferrites, heavy media, cattle feed, refractory and weighing materials, and for use in lead smelting.

TABLE 8
U.S. EXPORTS OF IRON ORE, BY COUNTRY OF DESTINATION[1, 2]

(Thousand metric tons and thousand dollars)

	2009		2010	
Country	Quantity	Value	Quantity	Value
Belgium	194	$18,600	107	$14,900
Canada	3,060	276,000	8,110	896,000
China	99	5,800	725	51,800
Colombia	20	1,210	9	899
Finland	--	--	35	3,440
France	179	17,200	236	33,000
Germany	234	22,400	341	47,700
Mexico	70	8,730	188	15,900
Serbia	--	--	44	5,980
Singapore	(3)	5	5	31
South Africa	53	5,050	--	--
Spain	--	--	156	21,800
Sweden	6	427	--	--
Other[4]	7 r	498 r	2	210
Total	3,920	356,000	9,950	1,090,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes agglomerates.

[3] Less than ½ unit.

[4] Includes all countries with less than 5,000 metric tons of exports from the United States in 2009 and 2010. This represents 16 countries in 2009 and 7 countries in 2010.

Source: U.S. Census Bureau.

TABLE 9

U.S. EXPORTS OF IRON ORE, BY TYPE OF PRODUCT[1, 2]

	2009			2010		
Type of product	Quantity (thousand metric tons)	Value (thousands)	Unit value[3, 4] (dollars per metric ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[3, 4] (dollars per metric ton)
Concentrates	123	$7,850	63.84	391	$30,200	77.20
Coarse ores	4	182	45.50	259	13,500	52.21
Fine ores	25	1,560	62.52	78	9,990	128.09
Pellets	3,760	346,000	92.10	9,220	1,040,000	112.61
Briquettes	3	259	86.33	5	31	6.20
Other agglomerates	(5)	22	80.00	1	82	82.00
Roasted pyrites	1	71	71.00	1	104	104.00
Total	3,920	356,000	90.97	9,950	1,090,000	109.70

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Includes agglomerates.

[3] Unit values shown are calculated from unrounded data.

[4] Weighted average calculated from unrounded data by dividing total value by total tonnage.

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10

U.S. IMPORTS OF IRON ORE, BY COUNTRY AND TYPE OF PRODUCT[1, 2]

	2009			2010		
Country and type of product	Quantity (thousand metric tons)	Value (thousands)	Unit value[3, 4] (dollars per metric ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[3, 4] (dollars per metric ton)
Country:						
Brazil	188	$13,100	69.65	506	$65,400	129.28
Canada	3,140	323,000	102.70	4,490	471,000	105.04
Chile	203	16,100	79.14	131	15,500	118.08
Finland	6	367	61.17	--	--	--
Mexico	55	4,610	83.73	138	12,400	89.55
Peru	34	1,670	49.03	16	1,370	85.50
Russia	136	8,240	60.60	606	69,900	115.35
South Africa	43	2,980	69.23	--	--	--
Sweden	31	3,190	102.74	54	7,240	134.07
Trinidad and Tobago	--	--	--	120	17,200	142.14
Ukraine	--	--	--	95	13,700	143.78
United Kingdom	8	1,630	203.75	--	--	--
Venezuela	21	825	39.29	251	28,600	113.98
Other[5]	8	226 [r]	28.25 [r]	12	615	51.25
Total	3,870	376,000	96.97	6,420	703,000	109.59
Type of product:						
Concentrates	283	22,300	78.95	652	78,600	120.50
Coarse ores	16	2,330	145.50	36	4,160	115.61
Fine ores	466	34,900	74.91	628	76,000	121.02
Pellets	3,100	315,000	101.90	5,100	544,000	106.77
Briquettes	4	159	39.75	4	178	44.50
Other agglomerates	3	104	34.67	--	--	--
Roasted pyrites	6	367	61.17	1	4	4.00
Total	3,870	376,000	96.97	6,420	703,000	109.59

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Includes agglomerates.

[3] Unit values shown are calculated from unrounded data.

[4] Weighted average calculated from unrounded data by dividing total value by total tonnage.

[5] Includes all countries with less than 5,000 metric tons of imports to the United States in 2009 and 2010. This represents 3 countries in 2009 and 6 in 2010.

Source: U.S. Census Bureau.

TABLE 11
U.S. IMPORTS OF IRON ORE IN 2010, BY COUNTRY AND TYPE OF PRODUCT[1, 2]

(Thousand metric tons)

Country of origin	Concentrates	Coarse ores	Fine ores	Pellets	Briquettes and other agglomerates	Roasted pyrites	Total
Brazil	295	(3)	135	76	--	--	506
Canada	(3)	--	394	4,090	--	--	4,490
Chile	131	--	--	--	--	--	131
Mexico	117	--	21	--	--	--	138
Peru	--	--	16	--	--	--	16
Russia	--	--	--	606	--	--	606
Sweden	--	--	54	--	--	--	54
Trinidad and Tobago	(3)	--	--	120	--	--	120
Ukraine	--	--	--	95	--	--	95
Venezuela	108	36	--	107	--	--	251
Other[4]	--	--	7	--	4	1	12
Total	652	36	628	5,100	4	1	6,420

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes agglomerates.

[3] Less than ½ unit.

[4] Includes all countries with less than 5,000 metric tons of imports to the United States. This represents six countries.

Source: U.S. Census Bureau.

TABLE 12
AVERAGE UNIT VALUE FOR SELECTED IMPORTS OF IRON ORE IN 2010[1]

Type of product	Country of origin	Average unit value[2] (dollars per metric ton, gross weight)
Concentrates	Brazil	123.95
Do.	Chile	117.92
Do.	Mexico	77.11
Do.	Venezuela	160.75
Fine ores	Brazil	135.35
Do.	Canada	114.89
Do.	Mexico	160.49
Do.	Sweden	135.00
Pellets	Brazil	138.90
Do.	Canada	104.09
Do.	Russia	115.36
Do.	Trinidad and Tobago	143.08
Do.	Ukraine	143.08
Do.	Venezuela	65.52

Do. Ditto.

[1] Includes agglomerates.

[2] Weighted averages of individual customs values.

Source: U.S. Census Bureau.

TABLE 13

U.S. IMPORTS OF IRON ORE, BY CUSTOMS DISTRICT[1, 2]

(Thousand metric tons and thousand dollars)

	2009		2010	
Customs district	Quantity	Value	Quantity	Value
Baltimore, MD	781	$67,400	1,980	$200,000
Charleston, SC	6	151	--	--
Chicago, IL	637	45,000	569	74,700
Cleveland, OH	1,860	213,000	2,740	300,000
Columbia-Snake, OR	--	--	21	3,370
Detroit, MI	--	--	(3)	11
El Paso, TX	--	--	55	3,000
Houston-Galveston, TX	38	3,510	76	10,500
Los Angeles, CA	(3)	1	--	--
Minneapolis, MN	--	--	(3)	3
Mobile, AL	28	2,270	179	24,500
New Orleans, LA	465	41,400	788	87,200
New York, NY	--	--	(3)	4
Nogales, AZ	3	175	--	--
Norfolk, VA	--	--	1	42
Ogdensburg, NY	18	325	8	169
Philadelphia, PA	6	367	--	--
Port Arthur, TX	8	1,630	3	348
Seattle, WA	28	513	--	--
St. Albans, VT	--	--	(3)	13
Total	3,870	376,000	6,420	703,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes agglomerates.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 14

U.S. IMPORTS OF PELLETS, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
Country	Quantity	Value	Quantity	Value
Brazil	38	$3,510	76	$10,500
Canada	2,900	303,000	4,090	426,000
Peru	5	283	--	--
Russia	136	8,240	606	69,900
Trinidad and Tobago	--	--	120	17,200
Ukraine	--	--	95	13,700
Venezuela	21	825	107	7,020
Total	3,100	315,000	5,100	544,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 15
IRON ORE: WORLD PELLETIZING CAPACITY, BY CONTINENT AND COUNTRY IN 2010[1]

	Rated capacity, gross weight (million metric tons)
North America:	
Canada	27.5 e
Mexico	15.0 e
United States	57.4 r
Total	99.9
South America:	
Brazil	56.0 e
Chile	5.3
Peru	3.5
Venezuela	11.8 e
Total	76.6
Europe and Central Eurasia:	
Kazakhstan	8.4 e
Netherlands	4.4 e
Russia	31.4 e
Slovakia	0.4
Sweden	24.2 r
Turkey	1.5 e
Ukraine	33.5 e
Total	103.8
Asia:	
Bahrain	11.0 r
China	110.0 e, r
India	20.7 r
Iran	12.3 e
Japan	3.0 e
Total	157.0
Oceania, Australia	4.3 e
Grand total	441.6

[e]Estimated. [r]Revised.

[1] Data may not add to totals shown because of independent rounding.

Sources: International Iron and Steel Institute; United Nations Commission on Trade and Development, Trust Fund on Iron Ore Information; U.S. Geological Survey.

TABLE 16

IRON ORE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[5]	Gross weight[3]					Metal content[4]				
	2006	2007	2008	2009	2010[e]	2006	2007	2008	2009	2010[e]
Algeria	2,340	1,982	2,077	1,307 [r]	1,469 [6]	1,180	1,030 [r]	1,050	700 [r]	786
Australia	275,000	299,000	342,000	394,000	433,000	171,000	194,000	209,000	228,000	271,000
Austria	2,093	2,153	2,033	2,002 [r]	2,050 [6]	669	689	650	641 [r]	658 [6]
Azerbaijan	11	18	28	--	--	6 [e]	9 [e]	14 [e]	--	--
Bosnia and Herzegovina	1,888 [r]	1,614 [r]	1,482 [r]	1,615 [r]	1,600	793 [r]	678 [r]	622 [r]	678 [r]	672
Brazil	317,800	354,674	350,984 [r]	310,000 [r]	370,000 [6]	211,020	235,504	233,000 [r]	199,200	240,000
Canada[7]	33,543	32,744	32,102 [r]	31,704 [r]	37,001 [p, 6]	21,341	20,751 [r]	20,300 [r]	20,000 [r, e]	23,300
Chile	8,628	8,818	9,316	8,242 [r]	9,130 [6]	5,235	5,379	5,670	5,006	5,852 [6]
China[e, 8]	601,000	707,000	824,000	880,000	1,070,000	198,000	233,000	270,000	280,000	332,000
Colombia	644	624	473 [r]	281 [r]	77 [6]	360 [r]	341 [r]	300 [r]	154 [r, e]	42
Cuba	8	3	--	--	--	4 [e]	2 [e]	--	--	--
Egypt[e]	1,600	665 [r]	773 [r]	1,780 [r]	1,000	800	335 [r]	390 [r]	890 [r]	500
Germany[9]	416 [r]	422	455	364 [r]	390	44	44	48 [e]	38 [r]	41
Greece[e, 10]	1,500	1,500	1,500	1,500	1,500	575	575	575	570	570
Guatemala	7	31	(11)	5	2 [6]	2 [r]	6 [r]	(11) [r]	1 [r]	(11)
India	177,000 [r]	207,000 [r]	215,000 [r]	225,000 [r, e]	230,000	113,000 [r]	126,000 [r]	138,000 [r]	144,000 [r, e]	147,000
Indonesia	88	61	65 [e]	45 [r]	46 [6]	50	35	37 [e]	25 [r]	26
Iran[e, 12]	26,244 [6]	31,538 [6]	32,000	26,000 [r]	28,000	13,000	15,000	15,000	12,000 [r]	13,000
Kazakhstan	22,263	23,834	21,486 [r]	22,281 [r]	24,229 [6]	12,700	13,600	12,200 [r]	12,700 [r]	13,800 [6]
Kenya[e]	(11) [r]	(11) [r]	(11) [r]	(11) [r]	(11)	(11) [r]	(11) [r]	(11) [r]	(11) [r]	(11)
Korea, North[e]	5,040	5,130	5,136 [6]	5,300 [r]	5,300	1,400	1,400	1,488 [6]	1,500 [r]	1,500
Korea, Republic of	227	291	366	455 [r]	513 [6]	155	163	205	274 [r]	308
Macedonia[e]	10	--	-- [6]	--	--	6	--	-- [6]	--	--
Malaysia	667	802	982	1,470 [r]	3,466 [6]	380 [e]	457 [e]	560 [e]	838 [r, e]	1,976 [6]
Mauritania	10,658	11,817	10,950 [r]	10,270 [r]	11,000	6,928 [r]	7,280 [r]	7,120 [r]	6,680 [r]	7,150
Mexico[13]	10,983	10,916	11,688	11,677 [r]	13,998 [6]	6,590	6,550	7,013	7,007 [r]	8,400
Mongolia	180	265	1,387	1,379 [r]	3,203 [6]	116	170	888	883 [r, e]	2,051 [6]
Morocco	9 [r]	9 [r, e]	9 [r, e]	31 [r]	45 [6]	5 [r]	5 [r, e]	5 [r, e]	16 [r]	23 [6]
New Zealand[14]	2,146	1,723	2,020	2,092 [r]	2,439 [6]	1,220 [e]	982 [e]	1,200 [e]	1,200 [r, e]	1,400
Nigeria[e]	88 [6]	58 [6]	62 [6]	50	50	32	21	23	16	16
Norway	620	620	668	711	712	420	400 [e]	430 [e]	460 [e]	460
Pakistan[15]	130	207	250	270 [e]	290	65	104	125 [e]	135 [e]	145
Peru	7,138	7,614	7,823	6,698	9,160	4,862	5,186	5,244	4,490 [r]	6,140
Portugal[e, 16]	14	14	14	14	14	10	10	10	10	10
Romania	123	45	--	--	--	40	11	--	--	--
Russia	102,000	105,000	99,900	92,000	101,000	59,100 [e]	60,800 [e]	57,800 [e]	53,200 [e]	58,500
Slovakia	583	570	392	-- [r]	--	198	194	133	-- [r]	--
South Africa[17]	41,326	42,083	48,983	55,313	58,709 [6]	26,000	26,500 [r]	30,800 [r]	34,800 [r]	37,300
Sweden	23,300 [e]	24,700 [e]	23,800	17,700	25,300	15,000 [e]	16,000 [e]	14,280	11,500	16,400
Thailand	264	1,555	2,029 [r]	1,401 [r]	1,400	132	779	855	800 [r, e]	800
Tunisia	214	180	211 [r]	151 [r]	165 [6]	112 [e]	94	110 [r]	79 [r]	86 [6]
Turkey	3,785	4,849	4,697 [r]	4,170 [r]	4,500	2,000 [e]	2,600	2,500 [e]	2,200 [r, e]	2,400
Ukraine	74,000	77,900	72,688 [r]	66,476	78,171 [6]	40,700 [e]	42,800 [e]	40,000 [e]	36,600 [r, e]	43,000
United Kingdom	(11)	(11) [e]	(11)	--	--	(11)	(11) [e]	(11)	--	--
United States	52,700	52,500	53,600	26,700	49,900 [6]	33,300	33,100	33,800	16,600	31,300 [6]
Venezuela[e]	22,100	20,700	20,650 [6]	14,900	14,000	14,500	13,600	13,600	9,800	9,200

See footnotes at end of table.

TABLE 16—Continued
IRON ORE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

	Gross weight[3]					Metal content[4]				
Country[5]	2006	2007	2008	2009	2010[e]	2006	2007	2008	2009	2010[e]
Vietnam[e]	1,020 [6]	1,060	1,000	1,000	1,000	510 [6]	530	530	530	530
Zimbabwe[e]	104 [6]	100	50	-- [6]	--	52	50	25	-- [6]	--
Total	1,830,000 [r]	2,040,000	2,210,000	2,230,000 [r]	2,590,000	964,000 [r]	1,070,000	1,130,000	1,090,000 [r]	1,280,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] Estimated data and world totals are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 22, 2011.

[3] Insofar as availability of sources permit, gross weight in this table represent the nonduplicative sum of marketable direct-shipping iron ores and iron ore concentrates; iron agglomerates produced from imported iron ores have been excluded under the assumption that the ore from which such materials are produced has been credited as marketable ore in the country where it was mined.

[4] Data represent actual reported weight of contained metal or are calculated from reported metal content. Estimated figures are based on latest available iron content reported, except for the following countries for which grades are U.S. Geological Survey estimates: Azerbaijan, Kazakhstan, North Korea, and Ukraine.

[5] In addition to the countries listed, Uganda may also produce iron ore, but definitive information on output levels, if any, is not available.

[6] Reported figure.

[7] Series represented gross weight and metal content of usable iron ore (including byproduct ore) actually produced, natural weight.

[8] China's gross weight iron ore production figures are significantly higher than that of other countries, because China reports crude ore production only with an average iron content of 33%, whereas other countries report production of usable ore.

[9] Iron ore is used domestically as an additive in cement and other construction materials but is of too low a grade to use in the steel industry.

[10] Nickeliferous iron ore.

[11] Less than ½ unit.

[12] Data are for year beginning March 21 of that stated.

[13] Gross weight calculated from reported iron content based on grade of 60% iron.

[14] Concentrates from titaniferous magnetite beach sands.

[15] Pakistan iron ore is based on a July-to-July fiscal year and 50% of production is used from each reported year.

[16] Includes manganiferous iron ore.

[17] Includes magnetite ore as follows, in thousand metric tons: 2006—3,830; 2007—3,781; 2008—3,987; 2009—4,725; and 2010—5,474.

IRON OXIDE PIGMENTS

By Arnold O. Tanner

Domestic survey data were prepared by Hoa P. Phamdang, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, natural iron oxide pigment (IOP) production in the United States decreased slightly compared with that of 2009. U.S. production data are withheld to avoid disclosing company proprietary data. Finished natural and synthetic IOPs sold by processors increased to 54,700 metric tons (t) valued at $80.7 million in 2010 from 50,800 t valued at $74.0 million in 2009. Exports of all grades of IOPs and hydroxides increased to slightly more than 54,000 t valued at $51.4 million in 2010 compared with 17,000 t valued at $34 million in 2009. Imports of natural and synthetic IOPs increased to 151,000 t valued at $167 million in 2010 compared with 106,000 t valued at $127 million in 2009.

Production

Natural IOPs, probably the most important of the natural minerals suitable for use as pigments after milling, are low cost, color stable, and nontoxic. They are derived from hematite, which is a red iron oxide mineral; limonite, a mineral that varies from yellow to brown, such as ochers, siennas, and umbers; and magnetite, a black iron oxide mineral. Synthetic IOPs are widely used as colorants and compete with natural IOPs in many color applications. They are manufactured using three methods: thermal decomposition of iron salts or iron compounds; precipitation of iron salts, usually accompanied by oxidation; and reduction of organic compounds by iron. Organic colorants are used for some colorant applications but several of organic compounds fade over time from exposure to sunlight.

U.S. production data for crude (natural) IOPs sold or used in 2010 were developed from a U.S. Geological Survey (USGS) voluntary survey of three companies, of which two responded. These data collected through the USGS survey are withheld to avoid disclosing company proprietary data. With a slight decrease in production, sales remained less than 50,000 t in 2010.

In a second voluntary USGS survey, production data for finished (natural and synthetic) IOPs received from seven of eight known processing operations, represented 90% of the tonnage shown in table 1. Data for the nonrespondent was estimated on the basis of prior-year levels of output and industry trends. Based upon this survey, sales of finished pigments were 54,700 t in 2010, up from 50,800 t in 2009. Production data for finished IOPs are collected only from operations that process material, such as the crushing and grinding of natural IOPs, or that synthesize IOPs, not operations that simply blend, mix, repackage, and (or) resell IOP material.

At least four U.S. companies, operating nine plants, produced regenerated iron oxide during steelmaking (table 2). Iron oxide is obtained during steelmaking when steel is treated with hydrochloric acid to remove surface oxides. Iron oxide is formed when the spent pickle liquor is treated to recycle the acid. Regenerated iron oxide data were not included in table 1 because it must be processed before it is suitable for use in typical iron oxide pigment applications.

Environment

Iron Oxide Recovery, Inc. (a subsidiary of Hedin Environmental, Mt. Lebanon, PA) processed iron sludge collected from acid mine drainage as part of the Upper Latrobe abandoned mine drainage treatment project near Unity, Westmoreland County, PA. The sludge was collected from a passive treatment system of three settling ponds created by directing water from a borehole drilled to a 43-meter deep pooling of the mine drainage. Drainage from three separate discharges had been polluting Loyalhanna Creek, a popular fishing and recreation area. The sludge was to be processed into a dry powder and sold as a natural pigment for cements, mulch, paints, paper, and plastics. The remediation and landfill disposal costs were eliminated in an environmentally safe manner and resultant product sales fully financed costs (Panian, 2010).

Consumption

End-use data for IOPs are not surveyed by the USGS or other organizations. Will (2008, p. 12) estimated that world consumption of natural IOPs and synthetic IOPs was 167,000 t and 1.13 million metric tons (Mt), respectively, in 2006. More recent data are unavailable, but the global economic downturn since 2008 likely resulted in decreased consumption of IOP in 2008 and 2009 as may be inferred by the decrease in reported world production of natural IOPs in 2009. In 2010, consumption of natural IOPs likely increased as compared with that of 2009 based upon reported increases in world production. Uses for natural IOPs were estimated to be construction materials (48%), coatings (42%), other unspecified applications (7%), and ceramic, glass, paint, paper, and plastic applications (3%). Uses for synthetic IOPs were estimated to be construction materials (48%), coatings (24%), other unspecified applications (21%), and ceramic, glass, paint, paper, and plastic applications (7%).

Construction materials included concrete products such as block, brick, or segmental retaining wall units; mortar; paving stones; precast products of various sizes or dimensions; ready-mixed concrete; and roofing tiles. IOPs are used almost exclusively to color decorative concrete. The tinted concrete is often stamped so that it resembles brick, slate, stone, and many more shapes and forms found in nature, including wood (Pinto, 2008, p. 4, 6).

Sales of IOPs in these construction markets increased but still experienced lingering negative effects from the sharp decline in domestic and foreign construction activity since 2008. In the United States, construction starts for new privately owned housing increased to 587,000 units in 2010 from 554,000 units in 2009 but were significantly lower than the 906,000 units started in 2008 (U.S. Census Bureau, 2011b). The value of all residential and commercial construction, both of which use tinted brick and concrete products, again decreased to $804 billion in 2010 from $903 billion in 2009 and $1.07 trillion in 2008 (U.S. Census Bureau, 2011a).

The second largest market for IOPs is as a tint in paints and coatings. The paint and coatings market experienced a modest increase in shipments in 2010 owing to increased construction and manufacturing activity, including those of the automobile industry. This followed decreased shipments in 2009 from those of 2008 owing to decreased construction and manufacturing activity during the economic recession. Shipments of total paint and allied products (comprising architectural coatings, original equipment manufacture product coatings, special-purpose coatings, and miscellaneous allied paint products) were 4.26 billion liters (1.13 billion gallons) in 2010 compared with 4.0 billion liters (1.06 billion gallons) in 2009 and 4.55 billion liters (1.2 billion gallons) in 2008 (U.S. Census Bureau, 2011c). Other end uses of IOPs included colorants for ceramics, glass, paper, plastics, rubber, and textiles; in foundry sands; industrial chemicals, such as catalysts; animal feed; cosmetics; ferrites; fertilizers; and magnetic ink and toner.

A major end use for regenerator iron oxides was ferrite ceramic magnets. There are two types of ferrites—hard, which retain magnetism permanently, and soft, which do not. Hard ferrites are used in flexible magnets, generators, loudspeakers, and motors. Uses of soft ferrites include computers, cores for radio frequency coils, inverter cores, memory cores, microwave communication systems, microwave ferrites for telecommunications, pot cores, rectangular modulus cores, television deflection yokes, and other industrial applications.

Rockwood Pigments NA, Inc. introduced a new generation IOP, SolaroxTM, which responds to sunlight, enabling surfaces to inhibit microbial growth, reduce air pollutants, and self-clean. Working with the University of Turin in Italy, Rockwood Pigments developed a process to merge IOPs with the photocatalytic properties of titanium dioxide. Solarox, attractive for its environmental properties, is suitable for use in construction materials such as concrete masonry, pavers, plaster, stucco, roofing materials, wall renderings, and decorative concrete; it was available in the complete range of black, red, and yellow IOP shades and could be blended into brown, buff, gold, and tan color combinations (Rockwood Pigments NA, Inc., 2010b).

Prices

The annual average producer price index (PPI) for IOPs under North American Industry Classification System code 325131–72 was 202.1 in 2010 (1983=100) compared with 200.2 in 2009. The PPI ranged between 192.7 and 213.9 in 2010, with the high being reached in December and the low in May. The PPI measured the average change in the selling prices charged by domestic producers of IOPs over time (U.S. Bureau of Labor Statistics, 2011). Unit values for finished natural and synthetic IOP sold by domestic producers ranged from $0.32 to $3.45 per kilogram, with an average unit value of $1.08 per kilogram.

LANXESS AG, a leading world producer of natural and synthetic IOPs, raised prices in the spring by as much as $135 (EUR 100) per metric ton and in December by up to $147 (EUR 110) per metric ton. The company cited increasing raw material costs, investments made to address environmental protection issues and maintain product quality, and rising energy and freight costs as the primary reasons for the increases (LANXESS AG, 2010b).

Rockwood Pigments, with manufacturing sites in Australia, China, France, Germany, Italy, the United Kingdom, and the United States, announced global price increases of 5% to 10% for selected products in its full range of natural and synthetic IOPs. Following 2 years of stable pricing, Rockwood Pigments cited increased raw material costs, energy prices, and transportation charges as reasons for the increases (Rockwood Pigments, NA, Inc., 2010a).

Foreign Trade

While commercial construction, a major market for IOP colorants in concrete, remained weak in the United States and much of Europe in 2010, U.S. exports of IOPs rose significantly. Exports of all grades increased to most world markets, especially to Asian markets, where economic recovery was taking place at a faster pace than in other regions.

U.S. exports of pigment-grade IOPs and hydroxides in 2010 totaled 9,500 t valued at $17.0 million, up from 5,640 t valued at $15.5 million in 2009. China was the leading destination of pigment-grade IOPs, accounting for 34% of U.S. exports, and Mexico was second with 21%. The average unit value of exports of pigment-grade IOPs and hydroxides was $1.79 per kilogram in 2010, down from $2.74 per kilogram in 2009 (table 3).

Exports of other grades of IOPs and hydroxides rose to 44,700 t valued at $34.4 million in 2009 compared with 11,300 t valued at $18.5 million in 2009. China, Canada, and Spain, in descending order, were the major destinations for exports of other grades of IOPs and hydroxides, accounting for 84% of the export tonnage. China, Spain, Canada, and Hong Kong, in descending order, accounted for the largest increases in exports of other grades of IOPs. The average unit value of exports of other grades of IOPs and hydroxides was $0.77 per kilogram in 2010, down from $1.63 per kilogram in 2009 (table 3).

U.S. imports of IOPs rose more than 40% to 151,000 t valued at $167 million in 2010 from 106,000 t valued at $127 million in 2009 (tables 1, 4). Unit values of imports of IOPs and hydroxides ranged from $0.50 to $2.06 per kilogram, depending on the type and grade. The average unit value of all IOP imports combined was $1.10 per kilogram in 2010 compared with $1.19 per kilogram in 2009. Micaceous IOP imports declined slightly, but their average unit value doubled. Imports of natural IOP grades averaged $0.71 per kilogram in 2010, compared with $0.56 per kilogram in 2009. The leading source was Cyprus, with 65% of the tonnage, followed by France with 12%. Synthetic IOP import grades averaged $1.11 per kilogram in 2010 compared with $1.20 per kilogram in 2009. The leading sources of synthetic IOP imports were China with

53% of the tonnage; Germany, 25%; Brazil, 7%; and Canada, 5%. Following the significant declining trend of 2007–09, the increase in imports showed some evidence of a possible increase in construction activity in the United States in 2010 (table 5).

World Review

Sixteen countries reported production of natural IOP in 2010. Production increased in Germany, India, and South Africa, decreased in Pakistan, and remained unchanged in most other countries (table 6). Production in Germany included synthetic IOP. A number of other countries, including Azerbaijan, China, Honduras, Kazakhstan, Russia, and Ukraine, produce iron oxide pigments, but output, probably substantial, was not reported and no basis was available for estimating output levels.

In the European Union, a decline in spending in the construction industries slowed in 2010 to less than 2%, much less than 2008–09 levels. Consumption of construction-focused pigments in 2010 was more than that of 2009, although less than that of 2007–08. Emerging markets, such as Africa, Brazil, China, and India, increased their consumption of pigment minerals. Traditional markets, such as Europe and the United States, are needed for the pigments industry to return to prior levels because many emerging countries remain much smaller volume markets (Roberts, 2011). LANXESS performed process and plant optimization to increase production and expand IOP production capacities at all of its Brazil, China, and Germany sites (LANXESS AG, 2010a).

In a study of the European coatings industry, Information Research Ltd. identified factors that continued to influence the market for pigments in the coatings industry. These included the elimination of heavy metals and heavy-metal salts as pigments and an increase in competitively priced high-performance pigments from the Far East. Inorganic pigments, although losing some appeal owing to barium, cadmium, or chromium content, continued to be preferred where heat, light, and chemical resistance properties were required. Growth in most sectors of the paint pigments market was between 2% and 4%. Innovation in the pigment industry in Europe is being driven by increasingly restrictive legislation, changing formulation practices, and increased use in functional applications (Paint and Coatings Industry, 2010).

China.—China increased its IOP production in the past 5 to 6 years, decreasing its dependence on imports from the United States. A rising demand for IOPs in China mainly was driven by the country's ongoing urbanization. Higher levels of construction activity and economic recovery from the global recession resulted in increased imports of IOPs from the United States in 2010 from those of 2009 (particularly for other grades of IOPs and hydroxides), but they were still only about one-half the levels of several previous years (table 3).

LANXESS began producing black iron oxide pigments at its new unit in Jinshan, Shanghai Province. The new 10,000-metric-ton-per-year (t/yr) plant is adjacent to the company's 28,000 t/yr yellow iron oxide production unit. The company was developing new markets for the bluish type of black IOPs in the Asia/Pacific region including Australia, China, and India. All plant wastewater was contained within a closed-circuit and directly linked to an industrial water treatment plant, resulting in the reduction of wastewater generated compared with similar production units in the region. The new unit recycled byproducts from other processes into high quality black IOPs. In April 2010, LANXESS completed phase I of technical improvements to the yellow iron oxide production unit, allowing that plant to run at full capacity. Phase 2 improvements (begun in 2009) were designed to reduce that plant's emissions by at least 15% and were scheduled for completion in 2011. While able to service customers globally, both plants principally supplied Asian markets (LANXESS AG, 2010a).

Spain.—Promindsa SA, which set a company record by selling 15,000 t of iron oxide in 2009, anticipated sales of 17,000 to 20,000 t in 2010. Of 2009 sales, 87% was exported to 57 countries. The Santa Rosa Mine, an underground mine outside Zaragoza, consists of a seam of hematite with an average purity of 85% to 90% Fe_2O_3 at depths of up to 250 meters. Promindsa sold its iron oxide as a red pigment for use in paints, roof tile, brick, and asphalt, but recently entered new markets with products for use in glass and ceramics (Moores, 2010).

Outlook

IOP production increased slightly worldwide in 2010 from that of 2009, reflecting a small recovery from the global economic recession, which caused decreased construction activity and lower demand for IOPs for coloring concrete and paint, the two major markets for IOPs.

Rockwood Pigments, a major global IOP producer, indicated that, following declines in sales of surface treatment and colored concrete products in North America and Europe in 2008–09, net sales stabilized somewhat in European markets in 2010, similar to 2008 levels, but remained lower in North America. Although the company was concerned that a continued slowdown in the construction industry in North America might negatively impact its results in 2011, having had overall increased sales of coating products in 2010, Rockwood Pigments expected the upward trend to continue in most market sectors in 2011 (Rockwood Holdings, Inc., 2011, p. 38).

Despite only modest recovery of the construction sector in western industrialized countries, LANXESS' pigment product sales rebounded in 2010. The company expected IOP demand to continue to increase in 2011, especially as a result of increases in construction in some emerging markets and developing countries such as China and India, where the United Nations reported a trend toward urbanization (LANXESS AG, 2011, p. 24, 71).

International Monetary Fund (IMF) forecasts for 2011 and 2012 were mostly unchanged. The world economy was expected to grow about 4.5% each year, with offsetting changes across various economies—advanced economies growing at about 2.5% and emerging and developing economies at about 6.5% (International Monetary Fund, 2011). Improvement in the global economy may result in increased activity in IOP markets in 2011–12. In North America, IOP markets may increase by 2% to 3% while those in Europe and Asia may increase by 3% or more and 5% or more, respectively.

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TABLE 1

SALIENT U.S. IRON OXIDE PIGMENTS STATISTICS[1]

		2006	2007	2008	2009	2010
Crude pigments sold or used:[2]						
Quantity	metric tons	W	W	W	W	W
Value	thousands	W	W	W	W	W
Finished pigments sold:[e, 3]						
Quantity	metric tons	70,300	88,100	83,300	50,800	54,700
Value	thousands	$69,300	$122,000	$116,000	$74,000	$80,700
Exports:[4]						
Quantity	metric tons	3,100	5,410	4,740	5,640	9,490
Value	thousands	$8,090	$15,900	$12,100	$15,500	$17,000
Imports for consumption:[3]						
Quantity	metric tons	199,000	178,000	155,000	106,000	151,000
Value	thousands	$159,000	$154,000	$164,000	$127,000	$167,000

[e] Estimated. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Mined.

[3] Natural (mined) and synthetic.

[4] Pigment grade.

TABLE 2
PRODUCERS OF IRON OXIDE PIGMENTS AND REGENERATED IRON OXIDES IN THE UNITED STATES IN 2010

Producers	Plant location
Crude pigments:	
Alabama Pigments Co., LLC	Green Pond, AL.
Hoover Color Corp.	Hiwassee, VA.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Finished pigments:	
Alabama Pigments Co., LLC	Green Pond, AL.
Dynamic Color Solutions, Inc.	Milwaukee, WI.
Hoover Color Corp.	Hiwassee, VA.
LANXESS Corp.	New Martinsville, WV.
New Riverside Ochre Co., Inc.	Cartersville, GA.
Prince Minerals, Inc.	Quincy, IL; and Bowmanstown, PA.
Rockwood Pigments NA, Inc.	Beltsville, MD; Cartersville, GA; King of Prussia, PA; Los Angeles, CA; and St. Louis, MO.
Regenerator iron oxides:	
American Iron Oxide Co.[1]	Allenport, PA; Portage, IN; and Rockport, IN.
ArcelorMittal Weirton Inc.	Weirton, WV.
Bailey-PVS Oxides, L.L.C.	Decatur, AL; Fairfield, AL; and Delta, OH.
International Steel Services, Inc.	Burns Harbor, IN; and Warren, OH.

[1] Division of International Steel Services, Inc.

TABLE 3
U.S. EXPORTS OF IRON OXIDES AND HYDROXIDES, BY COUNTRY[1]

	Pigment grade				Other grade			
	2009		2010		2009		2010	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Australia	166	$512	443	$1,220	5	$39	70	$74
Belgium	700	3,360	862	3,630	54	389	19	109
Brazil	235	1,210	172	883	105	222	274	595
Canada	61	81	61	114	6,800	11,800	9,390	15,400
China	2,280	2,360	3,250	2,730	190	436	22,600	5,520
France	78	488	44	144	18	111	35	572
Germany	54	140	47	69	79	547	59	625
Hong Kong	165	517	389	1,050	44	131	936	867
India	30	154	71	277	21	74	19	76
Italy	42	144	43	165	520	441	783	613
Japan	60	82	56	109	19	161	64	92
Korea, Republic of	662	3,910	--	--	138	437	63	513
Mexico	472	420	1,970	1,440	2,130	1,310	2,500	1,540
Spain	29	93	65	143	--	--	5,540	1,270
Taiwan	44	217	161	716	23	193	202	2,060
Thailand	20	116	8	44	27	80	35	26
United Kingdom	112	493	159	681	285	745	627	1,540
Other	427 r	1,180 r	1,690	3,600	871 r	1,340 r	1,450	2,940
Total	5,640	15,500	9,490	17,000	11,300	18,500	44,700	34,400

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF SELECTED IRON OXIDE AND HYDROXIDE PIGMENTS, BY TYPE[1]

Type	2009 Quantity (metric tons)	2009 Value[2] (thousands)	2010 Quantity (metric tons)	2010 Value[2] (thousands)	Principal sources, 2010 (metric tons)
Natural:					
Earth colors[3]	862	$440	2,330	$1,160	Cyprus, 2,180; Spain, 135.
Micaceous	1,040	633	1,030	1,230	France, 414; Germany, 208; China, 147; Austria, 137.
Total	1,900	1,070	3,360	2,390	
Synthetic:					
Black	25,100	36,600	34,200	38,900	Germany, 12,000; China, 7,870; Canada, 6,850; Italy, 3,520; Japan, 3,500.
Red	40,700	41,200	62,900	63,500	China, 44,400; Germany, 14,700; Italy, 1,250; Colombia, 1,220.
Yellow	37,500	45,300	49,100	58,700	China, 25,400; Germany, 10,600; Brazil, 10,100.
Other[4]	1,250	2,770	1,520	3,130	China, 588; Canada, 455; Mexico, 272.
Total	105,000	126,000	148,000	164,000	
Grand total	106,000	127,000	151,000	167,000	

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Includes those earth colors not elsewhere specified or included.

[4] Includes synthetic brown oxides, transparent oxides, and magnetic and precursor oxides.

Sources: U.S. Census Bureau and the U.S. International Trade Commission.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF IRON OXIDE AND IRON HYDROXIDE PIGMENTS, BY COUNTRY[1]

	Natural				Synthetic			
	2009		2010		2009		2010	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Austria	208	$247	137	$197	3	$52	6	$61
Belgium	--	--	--	--	2,340	1,640	14	85
Brazil	--	--	--	--	7,970	8,810	10,100	11,900
Canada	--	--	(3)	9	1,520	3,260	7,830	3,560
China	20	14	158	166	48,400	44,300	78,300	73,800
Colombia	--	--	--	--	1,400	1,880	2,020	2,460
Cyprus	686	332	2,180	1,030	--	--	--	--
France	163	127	414	326	148	520	166	998
Germany	37	42	208	268	29,600	38,100	37,300	44,300
Italy	(3)	2	35	163	7,510	13,000	6,420	12,200
Japan	--	--	1	11	3,870	12,600	3,620	12,700
Spain	786	285	219	164	241	192	308	193
Sweden	--	--	--	--	356	76	285	47
Other	2	24	5	53	1,100	1,550	1,400	1,900
Total	1,900	1,070	3,360	2,390	105,000	126,000	148,000	164,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

[3] Less than ½ unit.

Sources: U.S. Census Bureau and the U.S. International Trade Commission.

TABLE 6

NATURAL IRON OXIDE PIGMENTS: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1,2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010
Austria	5,000	5,000 [r]	5,000	4,000 [r]	4,000
Brazil	2,000	2,000	2,000	2,000	2,000
Cyprus, umber	12,000	12,000	12,000	12,000	12,000
France	2,791 [4]	2,800	2,800	2,800	2,800
Germany[5]	242,264	240,310	251,412	209,172	233,909 [4]
India, ocher	370,000	375,000	380,000	385,000	390,000
Iran	2,600	2,600	2,600	2,600	2,600
Italy	500	500	500	500	500
Lithuania	4	4	4	4	4
Pakistan, ocher	5,500	6,000	6,000	6,200 [r]	6,000
Paraguay, ocher	250	250	250	250	250
South Africa	590 [4]	232 [4]	39 [4]	183 [r,4]	244
Spain, ocher	140,000	140,000	140,000	140,000	140,000
Turkey[6]	206,000	260,000	220,000	100,000	100,000
United Kingdom, iron oxides and hydroxides[7]	8,913 [4]	8,000	8,000	8,000	8,000
United States	W	W	W	W	W

[r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Estimated data are rounded to no more than three significant digits.

[2] Table includes data available through April 20, 2011.

[3] In addition to the countries listed, a number of others undoubtedly produce iron oxide pigments, but output is not reported and no basis is available for formulating estimates of output levels. Such countries include Azerbaijan, China, Honduras, Kazakhstan, Russia, and Ukraine. Unreported output is probably substantial.

[4] Reported figure.

[5] Production includes natural and synthetic iron oxide pigments.

[6] Production includes micaceous iron oxide pigment and earth paints.

[7] Includes iron oxide pigments.

KYANITE AND RELATED MATERIALS

By Arnold O. Tanner

Domestic survey data and tables were prepared by Forest H. Morgan, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

The United States continued to be the world's leading producer of kyanite and mullite (calcined kyanite), with production estimated to be about 93,000 metric tons (t) in 2010 (table 3). Production of synthetic mullite in the United States was an estimated 40,000 t. Andalusite was mined and marketed as part of a mineral mixture at one U.S. operation, but data were withheld to avoid disclosing company proprietary data. There was no reported U.S. production of sillimanite. Refractory products continued to be a major end use for kyanite and related materials.

This report includes information on andalusite, kyanite, and sillimanite (all of which have the formula Al_2SiO_5), and mullite and synthetic mullite ($3Al_2O_3 \cdot 2SiO_2$). The first three minerals are the primary minerals of what is referred to as the kyanite group, especially in the United States where kyanite is prevalent, but are also known collectively (including natural mullite) as the sillimanite minerals. Mullite typically is the most desired of these minerals because of its superior refractory (heat resistant) properties and high strength, but it is rarely found in nature in quantities that are economical to develop. Mullite can be made by calcining kyanite at a high temperature (for example, above 1,450 °C), and synthetic mullite typically refers to mullite made by calcining certain mixtures of alumina- and silica-containing minerals and materials, including bauxite and kaolin, at similarly high temperatures.

Production

Kyanite Mining Corp. (KMC), which has been mining the kyanite deposits in central Virginia since 1945, was the sole U.S. producer of kyanite and kyanite-derived mullite. KMC operated two open pit mines, the East Ridge Mine and the Willis Mountain Mine, in Buckingham County, and beneficiated the ore into a marketable kyanite concentrate. The company also had two kilns at its Dillwyn, VA, facility, the Gieseke Plant, at which kyanite was converted into mullite. U.S. production data reported to the U.S. Geological Survey (USGS) were withheld to avoid disclosing company proprietary data. KMC produced one grade of kyanite, Virginia Kyanite, which contains between 55% and 60% Al_2O_3. A second product, Virginia Mullite, which KMC described as "a true mullite, not a synthetic blend," was produced by calcining kyanite (O'Driscoll, 2010b). In 2010, 93,000 t of kyanite was reported produced in the United States; this was an increase of about 34% compared with the reported production of 71,000 t in 2009 and nearing a return to the production level of 97,200 t in 2008 (Lassetter, 2010, 2011). The estimated value of kyanite produced in the United States in 2010 was nearly $28 million, an increase of about 33% compared with a revised estimate of $21 million in 2009. This was based upon an estimated average unit value for raw and worked kyanite that remained at about $300 per metric ton compared with that of 2009. KMC's mullite product contained about 80% mullite (Kyanite Mining Corp., 2006). C-E Minerals, Inc. (part of Imerys SA Group) produced synthetic mullite from calcined bauxitic kaolin near Americus, GA, that contained up to 87% mullite (C-E Minerals, 1997). Based on nongovernment estimates from previous years, U.S. production of synthetic mullite of about 40,000 t in 2010 had an estimated value of about $12 million.

KMC estimated that reserves at its two Virginia mines would last for 50 to 75 years. During the economic slowdown in 2009, KMC reengineered and replaced the iron reduction stage of its beneficiation process to produce a higher quality kyanite through significant removal of the iron in its product while also increasing recovery of kyanite and production capacities (O'Driscoll, 2010b).

In response to increasing demand, C-E Minerals restarted all its kilns in Andersonville, GA, in late 2009, and in early 2010, brought onstream a new sintered mullite rotary kiln, which added 75,000 metric tons per year (t/yr) to the company's existing production capacity (O'Driscoll, 2010a).

Piedmont Minerals Co., Inc. in Hillsborough, NC, mined a deposit containing andalusite combined with pyrophyllite and sericite. The company sold products containing blends of the three minerals to producers of ceramics and refractories.

Consumption

Kyanite increases in volume by 16% to 18% when calcined to mullite and can be used in its raw concentrate form in a refractory mixture to offset the shrinkage on firing of other components, especially clays. Andalusite expands irreversibly by about 4% to 6% when calcined and can be used directly in refractories in its raw state (Dickson, 2006; Lassetter, 2007). In other refractory applications, kyanite concentrate is calcined to mullite before being added to refractory mixes if the volume increase of the kyanite is not required in the mix. Mullite is resistant to abrasion and penetration of deleterious dusts, gases, and slags. It also has beneficial creep resistance, which limits physical deformation under load at high temperatures (Roskill Information Services Ltd., 1990, p. 56, 63).

Examples of refractories that contain andalusite, kyanite, or mullite include insulating brick, firebrick, kiln furniture, refractory shapes, and monolithic refractories (made of a single piece or as a continuous structure), including castables (refractory concrete), gunning mixes, mortars, plastics, and ramming mixes.

Monolithic refractories are supplied in unfired and unshaped form, in contrast to prefired and preshaped brick products, and may be gunned, hand packed, molded, poured, pumped, rammed, or vibrated into place (Moore, 2004).

Iron and steel production continued to be the leading user of refractories. World and U.S. crude steel output increased by about 15% and 38%, respectively, in 2010 from that of 2009, following decreases of 7% and 36%, respectively, in 2009 from that of 2008. The leading steel-producing countries and their shares of 2010 steel output of 1.41 billion metric tons were China, 44%; Japan, 8%; the United States, 6%; Russia, 5%; India, 5%; the Republic of Korea, 4%; and Germany, 3%. These countries accounted for more than 1.05 billion metric tons of steel production in 2010, representing a 14% increase in production from the same countries compared with that of 2009 (World Steel Association, 2011a). Other refractories users were the nonferrous metal and glass industries (Sweet, Dixon, and Snoddy, 2006). Other end uses of kyanite and related materials included brake shoes and pads, electrical insulating porcelains, foundry use, precision casting molds, sanitaryware and whiteware, and other products (Kyanite Mining Corp., 2006).

KMC found its traditional markets for kyanite strengthening and gradually coming back from the weakened markets of the economic recession of late 2008 and 2009, and the company was experiencing success in some new markets, such as ceramic foam filters and refractories for aluminum production (O'Driscoll, 2010a).

Foreign Trade

An estimated one-third of U.S. kyanite and mullite output was exported. Most of the material imported into the United States in 2010 was from France and South Africa and was presumed to be andalusite (table 2). In 2010, imports of andalusite decreased by 55% compared with those of 2009. No U.S. imports of kyanite or sillimanite were reported in 2010.

World Review

South Africa continued to be the leading producing country of andalusite, with an estimated 240,000 t produced in 2010 (table 3). France produced an estimated 65,000 t of andalusite. Although China is thought to be a producer of andalusite, kyanite, and sillimanite, detailed production data have been unavailable since 2003 (O'Driscoll, 2010b). India was the primary producer of sillimanite, with an estimated 16,800 t of sillimanite, and also produced 7,800 t of kyanite in 2010. Countries that are thought to be producers of synthetic mullite [sintered mullite and (or) fused mullite] include Brazil, China, Germany, Hungary, and Japan (Taylor, 2005).

For refractories markets in China, India, and Japan, the steel industry used 70% to 75% of the tonnage. Two of the world's largest refractories companies reported that the steel industry accounted for about 60% of their annual sales worldwide (Semler, 2007a).

In addition to the steady resurgence in the world's steel industry, a steady decline of inexpensive and readily available refractory bauxite from China contributed to an increasing interest in the development of resources of sillimanite minerals (O'Driscoll, Mike, 2010b).

Peru.—In northern Peru, andalusite resources that were within unconsolidated sand and gravels of the Tablazo Mancora flood plain and other unproven mineral resources were being evaluated. Andalusita S.A. (a subsidiary of Refractarios Peruanos S.A.) began andalusite production at a rate of 30,000 t/yr in 2009 and was expected to reach full capacity of 40,000 t/yr by mid-2010, but further information was not available. The primary andalusite grade being produced for refractory consumers, mainly in Asia, Europe, and North America, contained a minimum of 58% Al_2O_3 and a maximum of 0.8% Fe_2O_3 (O'Driscoll, 2010a).

South Africa.—Andalusite Resources (Pty.) Ltd. mined andalusite near capacity at its Maroeloesfontein Mine in Thabazimbi, Limpopo Province. The mine's full production capacity was 50,000 t/yr with an expected mine life of 20 years. With licenses to mine adjacent properties to the north of the current mine site, the company expected an additional 25 years of production at the same rate. Andalusite Resources' latest drilling program on other adjacent sites found larger reserves than expected, adding an additional 25 years of mine life, bringing the total to 70 years at 50,000 t/yr. Andalusite Resources planned to expand production in the region to 80,000 to 100,000 t/yr by the end of 2012. The company's main markets were in China, Europe, India, and South Africa (O'Driscoll, 2010b).

Outlook

Natural raw materials, such as andalusite and kyanite, continue to be important in refractory manufacturing. They may become increasingly sought after as alternative materials to bauxite in certain refractory applications owing to a decrease in readily available, comparatively inexpensive refractory bauxite from China. Demand for bauxite within China has increased, and the availability of quality bauxite for export has declined in recent years, in part owing to Chinese Government policies that have reduced bauxite (and other mineral) exports. Also, bauxite supplies were affected by government restrictions and closures at several mining and processing locations in China owing to environmental and safety controls (O'Driscoll, 2010b). In general, refractory producers have faced increasing challenges in obtaining the bauxite necessary to produce refractory products (Roberts, 2010).

For durable refractories, technology advances included increased use of synthetic mullite. Continuing improvements in the technologies used in the manufacture of refractories is expected, and the use of synthetic raw materials in the production of refractories also is likely to increase. Other general material use trends could include the increased development and use of monolithic products, as has been the case in Japan's steel industry for more than a decade, and potentially a gradual increase in the use of recycled refractory materials (Semler, 2007b).

China and Japan have been major locations for the production and consumption of refractories. Opportunities for market expansion could exist in other areas, such as the Commonwealth of Independent States, Eastern Europe, the Middle East, and Southeast Asia (Semler, 2007b).

For Canada, Mexico, and the United States, steel consumption was projected to increase in 2011 by nearly 11% because of stock rebuilding from the drawdown during the recession coupled with an ongoing recovery in the U.S. economy. Because of efforts by the Chinese Government to moderate growth, especially in its real estate sector, the growth in China's apparent steel use slowed in the latter part of 2010 and was projected to slow to about 5% in 2011. India's steel use was expected to increase by about 13% in 2011. India is on track to become the third leading steel consuming country in the world after China and the United States. World steel consumption was forecast to increase by nearly 6% in 2011 compared with that of 2010 (World Steel Association, 2011b).

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TABLE 1

PRICES OF KYANITE AND RELATED MATERIALS IN 2010

(Dollars per metric ton)

	Price
Kyanite, USA, ex-works, raw, 54% to 60% alumina.	233–332
Kyanite, USA, ex-works, calcined (mullite), 54% to 60% alumina, 22-ton lots	387–456

Source: Industrial Minerals, December 2010, p. 69.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF ANDALUSITE, KYANITE, AND SILLIMANITE[1, 2, 3]

Year	Quantity (metric tons)	Value[4] (thousands)
2009	4,880	$2,060
2010	2,180	938

[1] Most material is andalusite from South Africa. No kyanite or sillimanite imports were reported.

[2] Harmonized Tariff Schedule of the United States code 2508.50.0000.

[3] Data are rounded to no more than three significant digits.

[4] Customs value.

Source: U.S. Census Bureau.

TABLE 3
KYANITE AND RELATED MATERIALS: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country and commodity[3]	2006	2007	2008	2009	2010
Australia:					
Kyanite	1,000	1,000	1,000	1,000	1,000
Sillimanite[4]	300	300	300	300	300
Brazil, kyanite, marketable	600	600	600	600	600
China, unspecified	3,400	3,500	4,000	4,000	4,000
France, andalusite	65,000	65,000	65,000	65,000	65,000
India:					
Kyanite	7,000	7,300	7,500	7,700	7,800
Sillimanite	15,000	15,200	16,000	16,500	16,800
South Africa, andalusite	221,209 [5]	264,645 [5]	216,667 [5]	190,000 [r]	240,000
United States:					
Kyanite	102,000 [6]	118,000 [7]	97,200 [8]	71,000 [9]	93,000 [10]
Mullite, synthetic	40,000	40,000	40,000	40,000	40,000

[r] Revised.

[1] U.S. and estimated data are rounded to no more than three significant digits.

[2] Owing to incomplete reporting, this table has not been totaled. Table includes data available through April 29, 2011.

[3] In addition to the countries listed, a number of other nations produce kyanite and related materials, but output is not reported quantitatively, and no reliable basis is available for estimation of output levels.

[4] In addition, about 7,000 metric tons of sillimanite clay (also called kaolinized sillimanite) that contains 40% to 48% Al_2O_3 is produced.

[5] Reported figure.

[6] Source: Estimated based on data from Mine Safety and Health Administration, [undated], Mining industry accident, injuries, employment, and production data: Mine Safety and Health Administration (accessed March 9, 2009, via http://www.msha.gov/stats/part50/p50y2k/aetable.htm).

[7] Source: Lassetter, W.L., Jr., 2008, Kyanite, andalusite, sillimanite and mullite: Mining Engineering, v. 60, no. 6, June, p. 44–45.

[8] Source: Lassetter, W.L., Jr., 2009, Sillimanite minerals: Mining Engineering, v. 61, no. 6, June, p. 68–69.

[9] Source: Lassetter, W.L., Jr., 2010, Sillimanite minerals: Mining Engineering, v. 62, no. 6, June, p. 74–76.

[10] Source: Lassetter, W.L., Jr., 2011, Sillimanite minerals: Mining Engineering, v. 63, no. 6, June, p. 96–98.

LEAD

By David E. Guberman

Domestic survey data and tables were prepared by Elsie D. Isaac, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2010, domestic lead mine production of recoverable lead was 356,000 metric tons (t), a 10% decrease compared with that of 2009. Alaska and Missouri were the dominant producing States with significantly more than one-half of total domestic mine production. Two mines in Montana and Washington that had produced lead during the first half of 2009 were closed in 2010.

Lead was produced at 9 U.S. mines that employed about 1,500 people. The value of domestic mine production was $854 million, a 13% increase from the value of domestic mine production in 2009, despite a decline in production owing to an increase in the average price of lead in 2010. Primary lead metal was produced at a smelter-refinery in Missouri.

Secondary lead, derived principally from scrapped lead-acid batteries, accounted for 91% of refined lead production in the United States in 2010. Nearly all the secondary lead was produced by 7 companies operating 14 smelters. Domestic secondary lead production increased slightly from that of 2009.

Lead was consumed in about 76 U.S. plants to manufacture such products as ammunition; building-construction materials; covering for power and communication cable; lead oxides in ceramics, chemicals, glass, and pigments; lead sheet; solders for construction, electrical-electronic components and accessories, metal containers, and motor vehicles; and storage batteries.

World mine production of lead increased by 6%, to 4.14 million metric tons (Mt) from 3.90 Mt in 2009. The United States accounted for about 9% of global lead mine production compared with 10% in 2009 and was ranked third in the world. China and Australia were the two leading world lead producers in 2010 accounting for 45% and 15%, respectively, of global lead mine production. World production of refined lead (primary and secondary) increased by 7%, to 9.49 Mt in 2010 from 8.89 Mt in 2009. The United States was the second leading producer of refined lead in the world and accounted for 13% of global refined lead production. China produced about 44% of global refined lead production and was the leading producer of refined lead in 2010.

According to the International Lead and Zinc Study Group (ILZSG) (2011a, p. 8–9), consumption of refined lead increased by 7% to 9.56 Mt in 2010 from 8.93 Mt in 2009, following a slight decline in global lead consumption in 2009 from that in 2008. The leading refined-lead-consuming countries in 2010 were China, 44%; the United States, 15%; the Republic of Korea, 4%; and Germany, 4%. ILZSG data indicated that there was a global refined lead supply surplus of about 39,000 t by yearend 2010.

Lead-acid batteries, including starting-lighting-ignition (SLI) and industrial types, continued to be the dominant use of lead, accounting for about 90% of reported lead consumption. SLI battery shipments in North America totaled 119.6 million units in 2010, a 9% increase from those of 2009. This total included original equipment (OE) and replacement automotive-type batteries.

Following substantial declines that took place in the second half of 2008, lead prices steadily increased during 2009 and began to approach price peaks from early 2008. In January 2010, the London Metal Exchange Ltd. (LME) average cash price for lead was $1.07 per pound. Average monthly prices declined during the first half of the year to $0.77 per pound in June and then increased during the second half of 2010. By yearend 2010, LME prices had increased to $1.09 per pound, essentially the same as they were in January. The 2010 annual average LME cash price was $0.97 per pound, an increase of 25% from that of 2009, and the North American Producer price (the weighted average, based on 1993 production figures, of the list prices of those North American primary and secondary producers quoting list prices, in addition to those producers who have switched to LME pricing) increased by about 25% from that of 2009, to $1.09 per pound from $0.87 per pound.

Legislation and Government Programs

In April, the U.S. Environmental Protection Agency (EPA) announced that renovations and repairs of child care facilities, houses, and schools built before 1978 (when the use of lead-based paint in housing was banned by the Federal Government) must be conducted using safe practices to protect children and pregnant women from exposure to lead-based paint. Common renovation activities that disturb lead-based paint such as cutting, demolition, and sanding can generate lead chips and dust that are potentially harmful to adults and children. The EPA's Lead Renovation, Repair, and Painting Rule, finalized in 2008, required contractors to be trained and certified in lead-safe work practices and became effective on April 22, 2010. Lead-safe work practices reduce the potential exposure associated with disturbing lead-based paint. More than 160,000 workers in the construction and remodeling industries had received training as of April. The EPA also announced advanced notice of proposed rulemaking that would apply lead-safe work practices to renovations on public and commercial buildings (U.S. Environmental Protection Agency, 2010a).

In late August, the EPA denied a petition calling for a ban on the production and distribution of lead hunting ammunition. The EPA reached this decision because it does not have the legal authority to regulate this type of product (ammunition or firearms) under the Toxic Substances Control Act (TSCA). The petition, submitted in early August by several groups, had asked the EPA to prohibit the manufacture, processing, and distribution of bullets, fishing sinkers, and lead shot under the TSCA. In November, the EPA rejected the requested ban on the use of lead fishing sinkers. The EPA stated that lead sinkers were banned on many Federal lands and that several States had already banned or restricted the use of these products (U.S. Environmental Protection Agency, 2010b).

In early October, Doe Run Resources Corp. (St. Louis, MO) reached an agreement with the EPA, the Missouri Department of Natural Resources, and the U.S. Department of Justice to spend approximately $65 million to correct violations of several environmental laws at 10 of its lead mining, milling, and smelting facilities in southeast Missouri. The company will pay a $7 million civil penalty for violating several environmental regulations. The civil penalty payment was to be split evenly between the Federal and State governments. Doe Run also decided that it would shut down operations at its Herculaneum primary lead smelter by yearend 2013 instead of installing pollution control technologies that would reduce emissions. Herculaneum was the only primary lead smelter operating in the United States in 2010. The smelter was to operate with an EPA-mandated 117,935-t annual production limit until it is closed. The company also agreed to provide an initial $8.14 million in financial assurance to guarantee cleanup work at the Herculaneum facility, $23.7 million on upgrades at its other production facilities, and to establish a $28 to $33 million assurance trust fund for the continued cleanup of mining and milling facilities in Missouri (Schier, 2010; U.S. Environmental Protection Agency, 2010c).

Production

Mine.—In 2010, domestic mine production of recoverable lead was 356,000 t, a 10% decline compared with that of 2009. Lead mine production in the United States has declined by about 22% during the past 10 years owing to shutdowns and curtailments at zinc and lead mines, and no new significant domestic lead mines were opened. In 2010, there were 9 lead-producing mines operating in the United States compared with 19 lead-producing mines in 2000.

Alaska and Missouri contributed the major share of the U.S. mine output of lead. Lead mine production also was reported in Idaho. Lead-producing mines that had operated in Montana and Washington until early 2009 were closed during 2010. Domestic mine production data were collected by the U.S. Geological Survey (USGS) from a precious-metal and base-metal voluntary survey of lode-mine production (tables 1–4).

Teck Alaska Inc. (a wholly owned subsidiary of Teck Resources Ltd., Vancouver, British Columbia, Canada) operated the Red Dog zinc-lead mine in northwestern Alaska under a royalty agreement with NANA Regional Corp., the sole owner of the property. NANA is a corporation organized under the provisions of the Alaska Native Claims Settlement Act. During 2010, Teck reported a decrease in the production of zinc and lead contained in concentrates compared with that of 2009 owing to lower mill feed grades despite record mill throughput in 2010 at Red Dog. Production of lead in concentrate at Red Dog in 2010 decreased by about 16% to 110,000 t compared with 132,000 t of lead in concentrate in 2009. In May, Teck began mining the Aqqaluk deposit, adjacent to the main pit, where the economically recoverable mineral resources were nearly exhausted, and the first ore from Aqqaluk was processed at the mill in August. The near-surface weathered Aqqaluk ore milled in 2010 was a lower grade than ore that was processed from the main pit in 2009. The average lead grade of ore milled during the last quarter of 2010 was 5.0% compared to 6.3% during the same period in 2009. The Aqqaluk deposit was expected to provide sufficient ore to enable zinc and lead mining operations at Red Dog to continue until 2031. Teck expected to produce 85,000 t of lead in concentrate in 2011 with approximately 66% of mill feed coming from the Aqqaluk deposit (Teck Resources Ltd., 2011a, p. 32–34; 2011b, p. 22–23).

Teck's Pend Oreille zinc-lead mine in northeastern Washington was placed on care-and-maintenance status in February 2009 owing to reduced metal demand and weakened zinc prices. A core group of employees remained at Pend Oreille after the shutdown to facilitate a possible restart in the future, and all regulatory and environmental requirements were being met (Teck Resources Ltd., 2011a, p. 35).

In late January, Doe Run reported that an underground equipment fire had taken place at the company's Viburnum #29 lead-zinc-copper mine. Viburnum #29 is one of six lead-producing mines that Doe Run operates along the Viburnum Trend in southeastern Missouri. According to the company, a truck fire broke out in an underground haul road, and all employees were safely evacuated from the mine with the assistance of mine rescue teams. The fire caused the Viburnum #29 mine shaft to be shut down for 2 days following the incident. The company expected that loss of output during the shutdown would be minimal. Viburnum #29 normally produced 1,800 metric tons per day of ore containing about 4% lead, 0.5% zinc, and 0.2% copper. It is the least productive of the six mines that Doe Run operated in the Viburnum region. When Viburnum #29 was reopened, Doe Run blocked off the area of the mine where the fire had taken place for a U.S. Department of Labor investigation and shifted resources to resume production from other parts of the mine (Platts Metals Week, 2010a).

In 2010, Hecla Mining Co. (Coeur d'Alene, ID) continued to operate two lead-producing mines, the Greens Creek lead, gold, silver, and zinc mine near Juneau, AK, and the Lucky Friday lead, silver, and zinc mine in the Coeur d'Alene Mining District in northern Idaho. Total production of lead in concentrate in 2010 increased by 6% to 42,600 t from 40,200 t in 2009. A 14% increase in production of lead in concentrate at Greens Creek in 2010 compared with that of 2009 offset a slight decline in production at Lucky Friday during the same time period (Hecla Mining Co., 2011, p. 31).

Primary.—Doe Run produced primary lead at a smelter-refinery facility in Herculaneum, MO. Concentrates for the smelter-refinery were provided mainly from four Doe Run mills that were supplied with ore mined from six production shafts along the Viburnum Trend in southeastern Missouri. In 2010, domestic primary lead metal production was 115,000 t, an 11% increase compared with 103,000 t in 2009. In late 2008, Doe Run temporarily closed one of two blast furnaces at its primary lead smelter owing to the decline in lead prices and unfavorable market conditions. The company continued to operate the smelter with a single furnace in 2010. In late 2010, Doe Run announced that it would be shutting down the primary lead smelter in Herculaneum in 2013 as part of an agreement with Federal and State regulatory agencies and limiting annual refined lead production to 117,935 t until it was closed (more information can be found under the Legislation and Government Programs section).

In March, Doe Run unveiled a new primary lead processing technology that company officials estimated would reduce air, land, and water emissions by nearly 99% when compared to traditional processing methods. The new process would replace high-temperature, furnace-based lead smelting with a chemical process that could be cleaner, more efficient, and safer than smelting. Doe Run has been working with an Italian-based engineering partner, Engitec Technologies S.p.A., to develop this proprietary technology that uses a wet chemical process to selectively dissolve lead concentrate in a leaching reactor containing a solution of ferric fluoborate and then extract the lead from the solution using an electric current. The electrowinning extraction process is similar to technology currently used to extract zinc from concentrate but had not been used for producing primary lead. One of the environmental benefits of the production method is the ability to recycle the activated solution within the process indefinitely. Doe Run expected that the new processing technology would yield greater lead metal recovery rates than those achieved using current primary lead smelting methods. The company has operated a demonstration plant in southeastern Missouri since 2007 and, following the completion of a feasibility study, planned to evaluate possible site locations for a commercial-scale plant. Doe Run would need about $150 million to fund the construction of a commercial-sized plant and had set mid-2013 as a possible startup date (Doe Run Co., The, 2010; Troszkiewicz, 2010).

Secondary.—Domestic secondary production of refined lead in 2010 increased slightly to 1.14 Mt from 1.11 Mt in 2009. Secondary lead accounted for 91% of domestic lead refinery production, unchanged from that in 2009. Lead-acid batteries continued to be the dominant source of recoverable lead scrap, accounting for 94% of all lead produced from secondary sources. The domestic secondary statistics were derived by the USGS from a combined secondary producer and consumer survey that included data from monthly and annual surveys. In 2010, 14 companies producing secondary lead, exclusive of that produced from copper-based scrap, were surveyed; 11 responded, representing about 99% of the total production of secondary lead. Of the total lead recycled in 2010, the majority was produced by 7 companies operating 14 plants in Alabama, California, Florida, Indiana, Minnesota, Missouri, New York, Pennsylvania, Tennessee, and Texas. Production and consumption for the nonrespondents were estimated by using prior-year levels as a basis (tables 1, 4–8).

An air permit that was issued in February 2010 to Johnson Controls Inc. (JCI) (Milwaukee, WI) by the South Carolina Department of Health and Environmental Control for a planned secondary lead smelter in Florence, SC, became effective in August following a brief delay. The permit had been appealed by local groups owing to potential environmental concerns associated with the new facility, but JCI was able to work with the groups and addressed these concerns. The new $150 million secondary smelter was expected to produce as much as 120,000 metric tons per year (t/yr) of refined lead from used lead-acid batteries when it opens in summer 2012. The Florence location was chosen by JCI owing to its proximity to three existing JCI lead-acid battery distribution and manufacturing facilities and the lack of lead smelters in that region (CRU Lead Monitor, 2010).

Consumption

Reported U.S. consumption of refined lead increased by about 11% in 2010 compared with that of 2009. A 13% increase in lead used for lead-acid storage batteries and a slight increase in consumption for casting metals offset declines in ammunition, extruded products oxides, sheet lead, and solder end-use sectors. Consumption of lead in SLI and industrial type lead-acid storage batteries represented about 90% of the total reported consumption of lead (tables 5–8). Demand for lead is heavily reliant on the lead-acid battery industry and, in turn, the automotive sector. The BCI reported that North American shipments of SLI automotive batteries in 2010 totaled 119.6 million units, a 9% increase from those in 2009. The increase in battery shipments in 2010 followed 2 consecutive years that SLI automotive battery shipments declined on a year-by-year basis. Shipments of replacement SLI batteries in 2010 totaled 105.7 million units, 7% greater than those in 2009. Replacement batteries represented 88% of all North American battery shipments in 2010. North American shipments of OE SLI batteries were 13.9 million units in 2010, an increase of 29% from those of 2009. The increase in shipments of OE batteries was attributed to increased production of new vehicles during 2010 compared with production in 2009. Total domestic vehicle production (passenger cars and light commercial vehicles) in 2010 was about 7.6 million units compared with 5.6 million units produced in 2009. In 2010, there was an estimated 239 million vehicles in operation in the United States, and the average age of the vehicle fleet on the road in the United States increased to 10.2 years, the highest level in history. Maintenance requirements of the aging fleet kept the replacement battery market stable while consumption of OE batteries increased compared with those of the previous year. During the economic downturn that began in late 2008, consumers delayed preventative vehicle maintenance, such as exchanging older batteries for new units, opting instead to wait until batteries failed before replacing them (Battery Council International, 2011, p. 23–24; CRU International Ltd., 2011, p. 162).

Exide Technologies (Alpharetta, GA) planned to close two of its three lead-acid battery facilities in Reading, PA, beginning in early June 2010. The company was planning a multiphase closure of the battery formation plant and distribution center and expected to shift those activities to Exide facilities in other States. These closures would not affect production at Exide's lead-acid battery recycling facility in Reading (Platts Metals Week, 2010b).

Lead-acid batteries used in vehicles incorporating traditional internal combustion engines remained the backbone of global lead consumption in 2010. Many of the leading lead-acid battery producers were investing capital to research and develop battery technologies for the next generation of vehicles (partially driven by European Union regulations aimed at substantially reducing carbon dioxide emissions in new vehicles by 2012). Battery technologies such as absorbed glass mat (AGM) were considered feasible options for use in some hybrid-electric vehicles. In AGM batteries, the electrolyte in the battery is immobilized with a highly porous and absorbent microfiber glass mat. AGM batteries typically deliver considerably longer lifespans than traditional flooded lead-acid batteries, and their design makes them a preferred battery choice for use in vehicles that have start-stop technology. Vehicles equipped with start-stop technology (sometimes called microhybrids) use automatic stop-start functionality to cut power to the engine when the vehicle idles, reducing fuel consumption and emissions by as much as 12%. This technology is attractive to automobile manufacturers because it is relatively inexpensive to add to existing vehicle designs. Battery producers were preparing to have capacity to produce appropriate lead-acid batteries, like AGM, for the introduction of vehicles equipped with start-stop technology in the United States by 2012.

The Battery Council International (BCI) reported that the sales value of industrial-type lead-acid batteries in North America increased by about 17% ($215 million) in 2010 compared with those of 2009. The increases were reported for stationary power and motive power lead-acid batteries and were attributed to increases in unit sales coupled with greater lead prices compared with those of 2009. Overall, 2010 shipments of industrial-type lead-acid batteries were valued at about $1.50 billion. Stationary power batteries accounted for 55% of all industrial-type battery sales, and the remaining 45% was motive power batteries. In 2010, the value of sales of motive power lead-acid batteries used in industrial vehicles (97% of motive power segment) increased by 19% from those in 2009. The majority of the motive power batteries sold in 2010 was those used in industrial trucks such as forklifts and material handling equipment. Consumption of OE motive power batteries increased in 2010 owing to an increase in sales of new industrial trucks, such as forklifts, compared with those of 2009. This was thought to be reflective of increased warehouse activity owing to economic recovery from the downturn that began in 2008. In 2010, sales of stationary power type lead-acid batteries that were used in data centers, telecommunications, and uninterruptible power systems (UPS) applications increased by 15% from sales in 2009 owing to increased corporate spending (Cullen, 2011).

Metalico Inc. (Cranford, NJ) was a leading domestic producer of nonbattery lead-based products in 2010. Metalico's lead fabricating segment produced lead sheet, shot, strips, and various extruded products at four fabricating facilities. In 2010, sales of fabricated lead products were valued at $65.4 million, a 5% increase compared with lead fabrication sales in 2009. The change was attributed to an increase in the average sales price of fabricated lead products in 2010 compared with that of 2009, offsetting a decline in volume sold during that time peiod (Metalico Inc., 2011, p. 35).

Prices

The LME average cash price for lead was $2,368 per metric ton in January 2010, but by June it had declined by 28% to $1,703 per metric ton. Prices increased during the second half of the year and reached an average price of $2,412 per metric ton in December. Price increases in 2010 were not necessarily supported by the physical lead market, which was considered to be in surplus for the entire year. Stocks of refined lead held in LME warehouses increased by 42%, from 146,775 t in the beginning of January 2010 to 208,550 t by yearend 2010. Growth in the industrial sectors of many nations that typically consume significant quantities of lead, especially China and India, contributed to price increases in 2010. The loss of refined lead production capacity in China owing to temporary smelter shutdowns was another contributing factor to price increases during 2010. On an annual average basis, the LME cash and North American Producer prices in 2010 were up by $0.195 per pound (25%) and $0.220 per pound (25%) respectively, from the average prices of $0.780 per pound and $0.869 per pound, respectively, in 2009.

Foreign Trade

In 2010, imports of unwrought (refined) lead metal in pigs and bars for consumption totaled 271,000 t, an 8% increase from those of 2009. The leading source was Canada, accounting for 87% of unwrought lead metal imports. In 2010, imports from Mexico decreased by 28% to 29,400 t, and no unwrought lead was imported from Peru (a leading source of imported unwrought lead in recent years prior to plant closings). Total domestic exports of unwrought lead in 2010 was 77,700 t, essentially unchanged from that in 2009. Mexico was the leading destination for the unwrought lead exported in 2010, accounting for about 64% of all shipments. Domestic exports of lead in concentrate were 299,000 t, a 4% increase from those of the previous year. Nearly 81% of the lead in concentrate produced domestically was exported in 2010 and 96% of total lead in concentrate exports went to Canada, China, Japan, and the Republic of Korea. In 2010, lead in concentrate exports to China, Japan, and Mexico increased and exports to Canada and the Republic of Korea declined from those in 2009 (tables 10–12).

In 2010, the United States imported about 23.6 million SLI lead-acid batteries for consumption, a 9% increase from those of 2009. Mexico was the leading provider of SLI batteries, accounting for 66% of the SLI batteries imported in 2010. SLI batteries were also imported from China, Germany, the Republic of Korea, Spain, and Taiwan. The United States exported about 15.3 million spent SLI lead-acid batteries in 2010, 110% greater than those of 2009. The majority of those units (90%) were shipped to Mexico for recycling. The increase in exports of spent lead-acid batteries in 2010 reflected increased scrutiny from the EPA and U.S. Customs and Border Protection on the classification of lead-acid battery exports. The agencies had discovered that shipments of spent lead-acid batteries were frequently mislabeled and were incorrectly identified as lead waste and scrap. In 2010, more spent-lead acid batteries were correctly classified for export owing to the increased scrutiny.

World Review

World mine production of lead increased by 6% to 4.14 Mt in 2010. China was the leading producer accounting for about 45%

of the world total, followed by Australia, with 15%; the United States, 9%; Peru, 6%; and Mexico, 4% (table 13). This increase in mine production was primarily owing to increased production in Australia, China, Mexico, and Russia, offsetting decreases in Peru and the United States. In 2010, six lead-producing mines were opened, reopened, or expanded, adding 129,000 t/yr to global lead mine production capacity. The additional mine capacity was in Australia, Canada, Mexico, and Peru. No substantial lead mines were closed in 2010.

World production of refined lead (primary and secondary) increased by 7%, to 9.49 Mt in 2010 from 8.90 Mt in 2009. China was the leading producer of refined lead, accounting for 44% of world production, followed by the United States, with 13%; and Germany, 4% (table 14). A 13% increase in Chinese production of refined lead metal in 2010 compared with that of 2009 and smaller production increases in Belgium, Brazil, Canada, Germany, Japan, Kazakhstan, Mexico, Poland, Russia, Thailand, and the United States accounted for the majority of the global refined lead increase. Secondary (recycled) lead has accounted for an increasing portion of the total global lead supply during the past 11 years. Secondary lead production represented about 54% of total refined lead production worldwide in 2010 compared with 47% in 1999. In 2010, five lead smelters opened, primarily in China, adding about 388,000 t/yr of refined lead production capacity. Conversely, a lead smelter (100,000 t/yr capacity) was closed temporarily in China in late 2010 (International Lead and Zinc Study Group, 2011b, p. 5–6).

According to ILZSG, consumption of refined lead increased by 7% to 9.56 Mt in 2010 from 8.93 Mt in 2009, following a slight decline in global lead consumption in 2009 from that in 2008. The leading refined-lead-consuming countries in 2010 were China, 44%; the United States, 15%; the Republic of Korea, 4%; and Germany, 4%. Chinese consumption continued to drive global demand growth. Lead consumption throughout the remainder of Asia benefited from China's growth. This was partially offset by declining consumption in Western Europe. Chinese consumption was fueled by strong demand for automotive and stationary batteries used in backup power supply systems, telecommunication networks, and renewal energy storage applications. ILZSG data indicated that there was a global refined lead supply surplus of about 39,000 t by yearend 2010 compared with a surplus of about 57,000 t by yearend 2009 (International Lead and Zinc Study Group, 2011a, p. 8–9).

European Union.—Recylex S.A. (Paris, France), a leading lead producer in Europe, reported that in 2010 its two facilities in France and subsidiary in Germany processed 149,000 t of spent lead-acid batteries, a 14% increase compared with 131,000 t in 2009. The lead-bearing materials produced by these plants were sent to the company's two smelters in Belgium and Germany. During 2010, the operating performance of the company's main smelter, in Nordenham, Germany, was significantly affected by a temporary shutdown for 3 weeks in late 2010 owing to a damaged furnace. Total refined lead production from the company's smelters in 2010 was 122,000 t, a 2% increase compared with 120,000 t in 2009 (Recylex S.A., 2011, p. 10)

Australia.—In February, Magellan Metals Pty. Ltd. [a wholly owned subsidiary of Ivernia Inc., (Toronto)] announced that it had restarted operations at its Magellan Mine in Western Australia. Mining operations at Magellan had been suspended in April 2007 owing to environmental concerns associated with the transport of lead concentrate from the mine. The company had received approval to transport sealed bags of lead concentrate from the mine to the Port of Fremantle for export. The company proceeded with ramp-up operations during the rest of 2010 and expected to reach full production capacity (85,000 t/yr) by yearend. Total production of lead in concentrate in 2010 was 44,000 t. On December 31, 2010, the company received a stop order from the Acting Minister for Environment of Western Australia relating to the transport of lead concentrate from the mine owing to environmental concerns. The company ceased all mining operations immediately upon receipt of the order and remained closed during the first quarter of 2011 (Ivernia Inc., 2011, p. 2, 5).

Canada.—Xstrata plc's (Zug, Switzerland) Brunswick underground zinc-lead mine near Bathurst, New Brunswick, was the leading producer of lead in concentrate in Canada. The mine had production capacity to process 3.40 Mt of ore containing copper, lead, silver, and zinc on an annual basis. In 2010, Brunswick Mine produced 60,000 t of lead in concentrate, down by 9% from the 66,000 t produced in 2009. In 2010, Xstrata increased reserves at Brunswick Mine to extend the mine life to 2013, beyond its previously anticipated closure in early 2010 (Xstrata plc, 2011, p. 91, 99).

In 2010, Selwyn Resources Ltd. (Vancouver, British Columbia) and joint-venture partner, Yunnan Chihong Zinc and Germanium Co. Ltd., continued an exploration, permitting, engineering, and development program at the Selwyn Project in the eastern Yukon Territory. Selwyn Chihong Mining Ltd. was formed as a joint-venture company to advance the Selwyn Project to bankable feasibility study and production. In 2010, Selwyn Chihong completed an extensive diamond drilling program in the XY Central and Don deposits to upgrade mineral resources to the measured and indicated category. It also undertook exploratory drilling in the XY West deposit to confirm the continuity and extent of the high-grade mineral resources. Approximately $7.6 million was spent on environment and engineering studies to support the bankable feasibility study and permitting activities. The Selwyn project was one of the largest undeveloped resources of lead and zinc in the world according to the company. The latest resource estimates for the project, as of February 2009, included 16.06 Mt of indicated high-grade mineral resources, grading 4.23% lead. Selwyn's development schedule provided for initial ore production to begin in 2014 at rates that would produce about 65,000 t/yr of lead in concentrate (Selwyn Resources Ltd., 2011, p. 1–9, 13).

Teck announced that 2010 refined lead production at its metallurgical complex at Trail was 71,500 t, a slight decline from that of 2009 owing to operational issues at an oxygen plant that affected lead operations and planned maintenance activities during the fourth quarter of 2010. The required maintenance necessitated a 32-day shutdown of the lead smelter. By yearend 2010, the lead smelter had returned to full production. Teck expected to produce 80,000 t of refined lead at Trail in 2011 (Teck Resources Ltd., 2011a, p. 34).

China.—China continued to be the leading global producer and consumer of lead in 2010. China was also the leading producer of lead-acid batteries in the world. Between 1999 and 2009, China's surging demand for lead contained in lead-acid batteries was caused by tremendous growth in the production of automobiles, electric bicycles (e-bikes), and motorcycles, increasing by 23%, 74%, and 8%, respectively. The number of e-bikes in China had grown to more than an estimated 100 million by yearend 2010. Each e-bike needed at least one lead-acid battery per year, containing about 10 kilograms of lead, to operate, which translated to about 1 Mt of lead consumed for this use in 2009. Consumption of lead in China has increased by an average of 20% per year from 1999 to 2009 and was estimated to have increased by 7% to 4.21 Mt in 2010 from 3.93 Mt in 2009. In 2010, lead consumption for automotive lead-acid batteries (OE and replacement) and e-bikes increased from that in 2009 owing to global economic recovery and continued growth in those sectors. Lead in concentrate production in 2010 was 1.85 Mt, a 16% increase from the 1.60 Mt produced in 2009. Refined lead production in 2010 was 4.20 Mt, a 13% increase from the 3.71 Mt produced in 2009. In 2010, secondary lead production accounted for 32% of total refined lead production in China, compared with 22% in 2006. Secondary lead production was expected to continue to increase and approach 50% of total refined lead output by 2015. In 2010, 38,000 t of refined lead was imported, 78% less than in 2009 (International Lead and Zinc Study Group, 2010, p. 1–14; 2011a, p. 26).

In 2010, the Chinese Government continued to eliminate smaller lead mines and smelters in an attempt to consolidate production. Lead was one of several nonferrous metals targeted by the Government for consolidation and modernization, but a multitude of lead exposure and poisoning incidents from lead smelters and lead-acid battery plants during 2009–10 had increased pressure to clean up the lead industry and increase oversight of production. Many of these incidents involved the poisoning of children living in villages near lead plants and were often publicized globally by mainstream media. In August, the Ministry of Industry and Information announced that 17 lead smelters with capacity to produce about 266,000 t/yr of refined lead were targeted for elimination. The majority of these smelters were smaller operations with substantially less than 50,000 t/yr of refined lead production capacity. These closures were part of the The National Development and Reform Commission's twelfth 5-year plan (2011–15), which proposed to limit lead smelting capacity in China to 5.5 million metric tons per year (Mt/yr) by 2015 and eliminate all outdated capacity. The plan also advocated increasing self-sufficiency for mineral commodities by developing domestic reserves and increasing overseas investments. Recycled production of lead was to account for more than 30% of annual refined lead production by 2015. The plan called for consolidation that would lead to the 10 leading producers to account for 70% of annual refined lead output by 2015. Despite the closures of smaller smelters, it was expected that new larger smelters scheduled to open would allow for continued increases in total lead metal production. In 2010, construction was ongoing at four new lead smelters that were expected to add about 360,000 t/yr of refined lead capacity by 2011. More projects were planned for 2012 to 2013 (China Metal Market—Lead, Zinc & Tin, 2010a, p. 2; 2010b, p. 18; Metal-Pages, 2010).

In October, leading lead-acid battery manufacturer JCI announced that it was investing $118 million to build its third lead-acid battery plant in China. The company was in the process of substantially expanding its production capacity to meet the increased consumption of lead-acid batteries for automobiles and motorcycles. The new plant was scheduled to be built in Chongqing and increase JCI's lead-acid battery production capacity in China to 18 million batteries per year when completed in 2012. JCI planned to increase capacity to 30 million batteries per year by 2015. The company expected to select a location in northern China for a fourth lead-acid battery plant in late 2010 (Johnson Controls Inc., 2010).

India.—In support of its emerging industrial economy and automotive sector, mine and refined lead production increased in 2010 compared with that in 2009. Lead consumed for production of lead-acid batteries also increased. Hindustan Zinc Ltd. (HZL) (Udaipar), India's leading integrated zinc and lead producer, produced 609,000 t of mined zinc and lead in concentrate at its four active mines during the 9-month period that ended December 31, 2010, a 6% increase compared with production in the same period of 2009. Construction work continued at a new zinc and lead smelter in Rajpura Dariba that was expected to produce 100,000 t/yr of primary lead when completed in late 2011. HZL was also expanding production capacities at its Kayar, Rampura Agucha, and Sindesar Khurd zinc-lead mines for progressive commissioning from mid-2010 to 2012. Upon completion of all of these projects, HZL's total zinc and lead smelting capacity would be 1.06 Mt/yr. HZL's expanded production capacity could help satisfy some of the increased demand for lead in India, which has become reliant on imported lead during the past several years (Hindustan Zinc Ltd., 2011).

Mexico.—In September, Goldcorp Inc. (Vancouver, British Columbia, Canada) announced that it had reached commercial production levels at its Penasquito gold-silver-lead-zinc project in the northeast corner of the State of Zacatecas. Mill throughput during the last 4 months of 2010 averaged more than 70,000 metric tons per day (t/d), with peaks reaching 105,000 t/d. Production levels were ramping up during the first three quarters of the year. In 2010, Penasquito produced 44,000 t of lead in concentrate. During an expected 22-year mine life, Peñasquito was expected to produce an annual average of about 90,700 t/yr of lead in concentrate (Goldcorp Inc., 2011, p. 8, 48).

JCI's new secondary lead smelter in Monterrey commenced operations in November. The plant was ramping up output towards its design capacity of 132,000 t/yr of refined lead. The smelter had the ability to expand to 176,000 t/yr of refined lead capacity and was expected to recycle spent lead-acid batteries from Mexico and the Southwest United States. The new plant was the company's second lead recycling facility in the Monterrey area, with an existing 120,000 t/yr refined lead capacity operation at Cienega de Flores (CRU International Ltd., 2011, p. 149).

Peru.—In the second quarter of 2009, Doe Run Peru halted operations at its La Oroya metallurgical complex, 140 kilometers east of Lima owing to environmental and financial problems that kept it from obtaining copper, lead, and zinc concentrates to process. La Oroya had the capacity to produce 120,000 t/yr of refined primary lead. Unsure of the company's financial stability following the late 2008 decline in commodity prices, banks froze credit lines that the smelter needed for working capital to purchase feed concentrates from suppliers. By yearend 2009, Doe Run owed its concentrate suppliers $100 million and needed an additional $150 million to complete an ongoing environmental cleanup of La Oroya in which Doe Run had already invested $307 million. La Oroya produced 114,000 t of refined lead in 2008, the last full year that it was open. In 2010, the company was working with the Peruvian Government, the labor union representing its employees, and its creditors to formulate a plan that would allow Doe Run to restart operations at the facility and complete its environmental obligations. The company failed to comply with a 2009 requirement imposed by Peru's mining minister to acquire the necessary financing for clean up and restart of the smelter by July 24 or permanently close operations. By yearend, it was unclear if and when the smelter would restart operations (CRU Lead Monitor, 2010; Metal Bulletin, 2010).

Outlook

At its September 2011 meeting in Lisbon, Portugal, ILZSG forecast global increases in lead mine and refinery production as well as in lead consumption. Global lead mine production was expected to increase to 4.50 Mt in 2011, 8% greater than that in 2010, owing to greater output in China, India, and Mexico, which would offset projected production declines in Australia. Global refined lead metal production in 2011 was expected to increase by 7% (10.3 Mt), owing to production increases and new plants in Australia, China, Germany, India, the Republic of Korea, and Mexico. The majority of new primary and secondary refined lead capacity added in 2011 was expected to be in China (International Lead and Zinc Study Group, 2011c).

Global consumption of refined lead in 2011 was forecast to be 10.2 Mt, a 6% increase from that of 2010, according to ILZSG. The global increase in consumption was attributed to a 7% increase in use of refined lead in China owing to growth in the automotive, e-bike, and industrial battery sectors. Consumption in Europe, India, and the United States was expected to be greater in 2011 than in 2010. In North America, the BCI forecast that total shipments of SLI lead-acid batteries would increase slightly in 2011 from those in 2010. Provided that the majority of vehicles in the current fleet continue to be operated on a regular basis, the replacement SLI battery market was expected to remain stable in the near future. Shipments of OE batteries were expected to be heavily reliant on sales of new automobiles and production in North America which were expected to increase from 2010 to 2016. The BCI forecast that OE battery shipments would increase by about 15% during the time period from 2010 to 2016. Sales of industrial-type lead-acid batteries in North America were expected to increase by 8% in 2011 compared with sales of 2010 owing to increased demand for motive power and standby batteries from the business sector. Overall, ILZSG expected that production of refined lead would exceed consumption, and the lead market would remain in surplus of about 188,000 t by yearend 2011 (Battery Council International, 2011; Cullen, 2011; International Lead and Zinc Study Group, 2011c).

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TABLE 1

SALIENT LEAD STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Production:						
Mine, recoverable lead content:[2]						
Quantity	metric tons	419,000	434,000	399,000	395,000	356,000
Value	thousands	$715,000	$1,180,000	$1,060,000	$757,000	$854,000
Primary lead, refined content, domestic ores and base bullion	metric tons	153,000	123,000	135,000	103,000	115,000
Secondary lead, lead content	do.	1,160,000	1,180,000	1,140,000	1,110,000	1,140,000
Exports, lead content:						
Lead ore and concentrates	do.	298,000	300,000	277,000	287,000	299,000
Lead materials, excluding scrap	do.	68,500	56,500	74,800	82,000	83,500
Imports for consumption, lead content:						
Lead in base bullion	do.	539	1,990	2,740	844	602
Lead in pigs and bars	do.	331,000	263,000	309,000	251,000	271,000
Stocks, December 31, lead content:						
Primary lead	do.	W	W	W	W	W
At consumers and secondary smelters	do.	56,000 [r]	51,600 [r]	72,500	63,300	64,600
Consumption of metal, primary and secondary, lead content	do.	1,490,000	1,570,000	1,440,000	1,290,000	1,430,000
Price:						
North American Producer average, delivered[3]	cents per pound	77.40	123.84	120.33	86.87	108.91
London Metal Exchange, pure lead, cash average[3]	do.	58.00	117.00	94.79	77.95	97.42
World:						
Production, gross weight:						
Mine	metric tons	3,630,000 [r]	3,720,000 [r]	3,880,000 [r]	3,900,000 [r]	4,140,000
Primary refinery	do.	3,690,000 [r]	3,660,000 [r]	3,980,000 [r]	3,860,000 [r]	4,200,000
Secondary refinery	do.	4,200,000 [r]	4,420,000 [r]	4,600,000 [r]	4,860,000 [r]	5,090,000

[r] Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Lead recoverable after smelting and refining. Data in table 13 represent lead in concentrate.

[3] Platts Metals Week.

TABLE 2
MINE PRODUCTION OF RECOVERABLE LEAD IN THE UNITED STATES, BY STATE[1]

(Metric tons, lead content)

State	2009	2010
Alaska and Missouri	370,000	W
Idaho, Montana, Washington[2]	24,900	W
Total	395,000	356,000

W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] 2010 production only in Idaho.

TABLE 3
LEADING LEAD-PRODUCING MINES IN THE UNITED STATES IN 2010, IN ORDER OF OUTPUT[1]

Rank	Mine	County and State	Operator	Source of lead
1	Red Dog	Northwest Arctic, AK	Teck Alaska Inc.	Zinc-lead ore.
2	Brushy Creek	Reynolds, MO	Doe Run Resources Corp.	Lead ore.
3	Fletcher	do.	do.	Do.
4	Buick	Iron, MO	do.	Do.
5	Viburnum (#29 and #35)	Washington and Iron, MO	do.	Do.
6	Greens Creek	Juneau, AK	Hecla Mining Co.	Zinc-silver ore.
7	Lucky Friday	Shoshone, ID	do.	Silver ore.
8	Sweetwater	Reynolds, MO	Doe Run Resources Corp.	Lead ore.
9	Galena	Shoshone, ID	U.S. Silver Corp.	Silver ore.

Do., do. Ditto.

TABLE 4
LEAD RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY[1]

(Metric tons, lead content, unless otherwise specified)

		2009	2010
Kind of scrap:			
New scrap:			
Lead-base		20,100	22,600
Copper-base		NA	NA
Tin-base		1,530	1,530
Total		21,600	24,100
Old scrap:			
Battery-lead		1,040,000	1,070,000
All other lead-base		47,400	42,900
Copper-base		NA	NA
Total		1,090,000	1,110,000
Grand total		1,110,000	1,140,000
Form of recovery:			
As soft lead		960,000	962,000
In antimonial lead		151,000	175,000
In other lead alloys		(3)	(3)
In copper-base alloys		NA	NA
Total:			
Quantity		1,110,000	1,140,000
Value[2]	thousands	$2,130,000	$2,730,000

NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Value based on average quoted price of common lead.

TABLE 5

U.S. CONSUMPTION OF LEAD, BY PRODUCT[1]

(Metric tons, lead content)

SIC[2] code	Product	2009	2010
	Metal products:		
3482	Ammunition, shot and bullets	67,900	65,700
	Bearing metals:		
35	Machinery except electrical	W	W
371	Motor vehicles and equipment	W	W
37	Other transportation equipment	W	W
	Total	1,100	1,230
3351	Brass and bronze, billets and ingots	1,370	1,410
36	Cable covering, power and communication	(3)	(3)
15	Calking lead, building construction	(3)	(3)
	Casting metals:		
36	Electrical machinery and equipment	W	W
371	Motor vehicles and equipment	W	W
37	Other transportation equipment	W	W
3443	Nuclear radiation shielding	W	W
	Total	15,900	16,400
	Pipes, traps, other extruded products:		
15	Building construction	1,130	990
3443	Storage tanks, process vessels, etc.	(4)	(4)
	Total	1,130	990
	Sheet lead:		
15	Building construction	16,300	16,000
3443	Storage tanks, process vessels, etc.	W	W
3693	Medical radiation shielding	W	W
	Total	25,400	23,400
	Solder:		
15	Building construction	W	W
	Metal cans and shipping containers	W	W
367	Electronic components, accessories, and other electrical equipment	6,160	6,130
371	Motor vehicles and equipment	W	W
	Total	6,450	6,420
	Storage batteries:		
3691	Storage battery grids, post, etc.	389,000	478,000
3691	Storage battery oxides	750,000	806,000
	Total storage batteries	1,140,000	1,280,000
27	Type metal, printing and allied industries	(3)	(3)
34	Other metal products[5]	5,790	8,800
	Grand total	1,260,000	1,410,000
	Other oxides:		
285	Paint	W	W
32	Glass and ceramics products	W	W
28	Other pigments and chemicals	W	W
	Total	10,100	9,760
	Miscellaneous uses	12,200	13,700
	Grand total	1,290,000	1,430,000

W Withheld to avoid disclosing company proprietary data; included in appropriate totals.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] SIC Standard Industrial Classification.

[3] Included with "Metal products: Other Metal products."

[4] Included with "Metal products: Sheet lead: Building construction" to avoid disclosing company proprietary data.

[5] Includes lead consumed in foil, collapsible tubes, annealing, galvanizing, plating, electrowinning, and fishing weights.

TABLE 6
U.S. CONSUMPTION OF LEAD IN 2010, BY STATE[1, 2]

(Metric tons, lead content)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California and Washington	25,600	1,010	1,890	--	28,500
Illinois	10,800	16,000	--	--	26,800
Iowa, Michigan, Missouri	12,100	34,500	W	--	46,600
Ohio and Pennsylvania	108,000	87,000	39,500	W	235,000
Arkansas and Texas	56,400	19,800	--	--	76,100
Alabama, Georgia, Oklahoma	28,300	5,760	W	--	34,100
Indiana, Kansas, Kentucky, Minnesota, Nebraska, Tennessee, Wisconsin	134,000	101,000	28,800	W	263,000
Connecticut, Maryland, New Jersey, New York, North Carolina, South Carolina	2,560	538	64	--	3,160
Various States	515,000	75,600	127,000	602	718,000
Total	893,000	341,000	197,000	602	1,430,000

W Withheld to avoid disclosing company proprietary data; included in "Various States." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes lead that went directly from scrap to fabricated products.

TABLE 7
U.S. CONSUMPTION OF LEAD IN 2010, BY CLASS OF PRODUCT[1, 2]

(Metric tons, lead content)

Product	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	54,900	63,600	W	W	124,000
Storage batteries	814,000	277,000	192,000	--	1,280,000
Miscellaneous[3]	23,500	(4)	W	W	23,500
Total	893,000	341,000	197,000	602	1,430,000

W Withheld to avoid disclosing company proprietary data; included in "Total." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes lead that went directly from scrap to fabricated products.

[3] Included in "Miscellaneous" are other oxides and gasoline additives.

[4] Withheld to avoid discosing proprietary data; included in "Storage batteries."

TABLE 8
STOCKS OF LEAD AT CONSUMERS AND SECONDARY SMELTERS IN THE UNITED STATES, DECEMBER 31[1, 2]

(Metric tons, lead content)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
2009	33,200	19,900	W	W	63,300
2010	29,000	25,000	W	W	64,600

W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes stocks at primary refineries.

TABLE 9

PRODUCTION AND SHIPMENTS OF LEAD PIGMENTS AND OXIDES IN THE UNITED STATES[1,2]

(Metric tons and dollars)

	2009				2010			
	Production		Shipments[e]		Production		Shipments[e]	
Product	Gross weight	Lead content	Quantity (lead content)	Value[3]	Gross weight	Lead content	Quantity (lead content)	Value[3]
Litharge, red lead and white lead, dry	--	--	2,520	$3,400,000	--	--	3,450	$7,000,000
Leady oxide	784,000 [r]	745,000 [r]	NA	NA	1,050,000	996,000	NA	NA
Total	784,000 [r]	745,000 [r]	NA	NA	1,050,000	996,000	NA	NA

[e] Estimated. [r] Revised. NA Not available. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes basic lead sulfate to avoid disclosing company proprietary data.

[3] At plant, exclusive of container.

TABLE 10

U.S. IMPORTS FOR CONSUMPTION OF LEAD PIGMENTS AND COMPOUNDS, BY KIND[1]

Kind	Quantity (metric tons, lead content)	Value (thousands)
2009:		
Chrome yellow, molybdenum orange pigments, lead-zinc chromates	1,270	$6,840
Litharge	971	2,570
Glass frits (undifferentiated)	25,800	37,400
Total	28,100	46,800
2010:		
Chrome yellow, molybdenum orange pigments, lead-zinc chromates	1,900	9,760
Litharge	1,470	5,440
Glass frits (undifferentiated)	25,300	45,900
Total	28,600	61,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 11

U.S. EXPORTS OF LEAD, BY COUNTRY[1]

Country	2009		2010	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ore and concentrates, lead content:				
Belgium	646	$268	4,320	$4,830
Canada	44,700	60,700	32,200	58,700
China	159,000	151,000	173,000	243,000
Japan	20,500	16,200	55,000	119,000
Korea, Republic of	61,100	45,400	26,300	37,600
Mexico	545	885	7,490	7,800
Other	419 [r]	157 [r]	274	140
Total	287,000	275,000	299,000	472,000
Base bullion, lead content:				
Mexico	25	99	99	371
Other	9	14	100	387
Total	34	113	199	757
Unwrought lead and lead alloys, lead content:				
Belgium	9,550	8,500	18,200	16,400
Brazil	2,200	2,440	11	8
Canada	5,390	8,780	6,670	10,400
Chile	955	1,240	336	277
China	252	232	1,290	1,980
Japan	87	1,130	515	1,930
Mexico	58,400	56,900	49,900	51,800
Other	763 [r]	822 [r]	839	1,230
Total	77,600	80,100	77,700	84,100
Wrought lead and lead alloys, lead content:				
Canada	1,370	3,090	1,540	3,520
Chile	244	942	34	115
China	165	231	200	192
Germany	24	46	257	278
Haiti	162	160	113	107
India	669	731	824	1,060
Mexico	705	1,170	947	1,160
United Kingdom	599	786	607	630
Other	373 [r]	1,140 [r]	1,070	2,120
Total	4,310	8,280	5,590	9,170
Scrap, gross weight:				
Canada	79,000	37,700	8,060	8,770
China	5,150	3,660	1,810	989
India	11,000	2,900	2,290	3,540
Korea, Republic of	31,800	21,500	20,700	15,500
Mexico	366	556	643	1,310
Pakistan	971	184	20	15
Panama	121	123	171	274
Spain	700	379	--	--
Taiwan	4,320	1,470	5,270	1,600
United Kingdom	477	105	19	32
Venezuela	493	201	45	48
Vietnam	1,530	488	210	69
Other	4,350 [r]	2,740 [r]	4,320	1,660
Total	140,000	72,000	43,500	33,800

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 12

U.S. IMPORTS FOR CONSUMPTION OF LEAD, BY COUNTRY[1]

Country	2009		2010	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Base bullion:				
Canada	--	--	404	$817
Mexico	810	$2,200	159	806
Other	34	52	38	94
Total	844	2,250	602	1,720
Pigs and bars, lead content:				
Canada	205,000	354,000	237,000	522,000
Colombia	18	29	97	159
France	267	1,080	730	2,210
Germany	11	32	7	68
Italy	--	--	240	96
Kazakhstan	3,500	4,460	--	--
Mexico	41,100	47,200	29,400	25,800
Peru	991	1,210	--	--
Russia	131	240	3,380	7,150
Other	94 r	125 r	424	805
Total	251,000	408,000	271,000	559,000
Reclaimed scrap, including ash and residues, lead content:				
Canada	785	1,900	621	1,500
China	32	26	21	5
Colombia	105	212	1,560	3,950
Mexico	348	357	402	732
Russia	18	28	--	--
United Kingdom	--	--	616	1,580
Other	46	99	515	1,120
Total	1,330	2,620	3,730	8,880
Wrought lead, all forms, including wire and powders, gross weight:				
Argentina	269	502	165	423
Canada	164	501	133	426
Egypt	20	44	100	301
Germany	709	3,740	744	4,130
Mexico	--	--	6	229
New Zealand	15	229	--	--
United Kingdom	123	216 r	95	322
Other	43 r	260	47	441
Total	1,340	5,490	1,290	6,270

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 13
LEAD: WORLD MINE PRODUCTION OF LEAD IN CONCENTRATE, BY COUNTRY[1,2]

(Metric tons, lead content)

Country[3]	2006	2007	2008	2009	2010
Argentina	12,064	17,045	20,788	24,753 [r]	22,000
Australia	686,000	641,000	645,000	566,000	625,000
Bolivia	11,955	22,798	81,602	84,535 [r]	72,803
Bosnia and Herzegovina[e]	1,000	2,600 [r]	3,300 [r]	2,100 [r]	2,000
Brazil	15,764	24,574	24,600	24,800	25,000 [p]
Bulgaria[e]	10,000	15,000	15,000	12,000 [r]	12,000
Burma[e]	2,000	2,000	3,000 [r]	7,500 [r]	7,000
Canada	83,096	75,135	98,974	68,761	64,859 [p]
Chile	672	1,305	3,985	1,511	900 [e]
China[e]	1,330,000	1,410,000	1,500,000	1,600,000	1,850,000
Georgia[e]	400	400	400	400	400
Greece[e]	10,500	15,000	16,000	16,000	18,000
Guatemala	28	165 [r]	53 [r]	--	--
Honduras	11,775	10,215	12,545 [r]	14,471 [r]	13,000
India	69,200	77,500	87,300	92,000	95,000
Iran[e, 4]	24,000 [5]	25,000	26,905 [r, 5]	30,000 [r]	30,000
Ireland[e]	62,000	54,100	50,200	43,000 [r]	45,000
Italy[e]	800	800	800	800	800
Japan	777	--	--	--	--
Kazakhstan	48,100	40,200	39,000	39,400	36,100
Korea, North[e]	13,000	13,000	13,000	13,000	13,000
Korea, Republic of	17	12	449	2,064 [r]	2,000 [e]
Macedonia	15,600	32,000	34,000 [e]	52,000	46,000
Mexico	120,450	120,000	100,725	143,838	158,206
Morocco	53,000	44,800	40,000	40,000 [e]	35,000
Namibia	11,830	10,543	14,062	20,000 [r]	20,000 [e]
Peru	313,325	329,154	345,109	302,459 [r]	261,902
Poland	97,600 [r]	79,400 [r]	87,700 [r]	80,400 [r]	70,000 [e]
Romania	6,269	1,000	-- [e]	-- [e]	-- [e]
Russia[e]	36,000	50,000	60,000	70,000	97,000
Serbia[e]	1,400 [r]	1,600 [r]	1,600 [r]	1,800 [r]	2,000
South Africa	48,273	41,857	46,440	49,149	49,715
Sweden	76,800	62,100	60,000	60,000 [e]	60,000 [e]
Tajikistan[e]	800	800	800	800	800
Turkey[e]	13,000 [r]	32,000 [r]	25,000 [r]	26,000 [r]	27,000
United Kingdom[e]	500	500	500	500	500
United States	429,000	444,000	410,000	406,000	369,000
Vietnam	14,900	19,200	14,200 [r]	7,700 [r]	7,000 [e]
Total	3,630,000 [r]	3,720,000 [r]	3,880,000 [r]	3,900,000 [r]	4,140,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 7, 2011.

[3] In addition to the countries listed, lead is also produced in Nigeria, but information is inadequate to formulate reliable estimates of output levels.

[4] Year beginning March 21 of that stated.

[5] Reported figure.

TABLE 14

LEAD: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010
Algeria, secondary[e]	5,000	5,000	5,000	5,000	5,000
Argentina:					
Primary	12,064	11,588	13,482	12,558 [r]	12,000 [e]
Secondary	37,000	49,000	59,000	70,000 [r, e]	70,000 [e]
Total	49,064	60,588	72,482	82,558 [r]	82,000 [e]
Australia:					
Primary	206,000	202,000	221,000	204,000	178,000
Secondary[e]	27,000	27,000	27,000	25,000	26,000
Total	233,000	229,000	248,000	229,000	204,000
Austria, secondary	28,120	28,564	26,902	23,000 [r, e]	24,000 [e]
Belgium:					
Primary	-- [r]	-- [r]	-- [r]	-- [r]	--
Secondary	101,400 [r]	117,200 [r]	109,000 [r]	109,000 [r]	121,000 [e]
Total	101,400 [r]	117,200 [r]	109,000 [r]	109,000 [r]	121,000 [e]
Bolivia	318	301	473	269 [e]	-- [e]
Brazil, secondary	108,951 [r]	130,963 [r]	95,704 [r]	96,000 [r]	112,000 [e]
Bulgaria:[e]					
Primary	64,000	73,000 [4]	73,000	70,000	68,000
Secondary	12,000	14,000 [4]	14,000	13,000	13,000
Total	76,000	87,000 [4]	87,000	83,000	81,000
Burma, primary	537	165	202	200 [e]	--
Canada:					
Primary	115,989	95,577	105,526	101,484	105,836 [p]
Secondary	134,475	141,111	153,549	157,370	167,042 [p]
Total	250,464	236,688	259,075	258,854	272,878 [p]
China:[e]					
Primary	2,130,000	2,140,000	2,350,000	2,480,000	2,840,000
Secondary	590,000	650,000	850,000	1,230,000	1,360,000
Total	2,720,000	2,790,000	3,200,000	3,710,000	4,200,000
Czech Republic, secondary[e]	29,000	34,000	36,000	29,000 [r]	30,000
Estonia, secondary	9,000	10,000	10,000 [e]	10,000 [e]	10,000 [e]
France:					
Primary[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Secondary	100,195	100,200	88,000	88,000 [e]	88,000 [e]
Total	100,195 [r]	100,200 [r]	88,000 [r]	88,000 [r, e]	88,000 [e]
Germany:					
Primary	113,760	110,934	113,200	104,900 [r]	125,000 [e]
Secondary	265,190	294,147	301,900	285,700 [r]	280,000 [e]
Total	378,950	405,081	415,100	390,600 [r]	405,000 [e]
Greece, secondary[e]	5,000	5,000	5,000	4,000	4,000
India:					
Primary	49,600 [r]	53,800 [r]	62,000	62,000 [r]	60,000 [e]
Secondary	170,000 [r]	185,000 [r]	212,000 [r]	245,000 [r]	253,000 [e]
Total	219,600 [r]	238,800 [r]	274,000 [r]	307,000 [r]	313,000 [e]
Indonesia, secondary	19,000	18,500	18,500	18,000	18,000
Iran:[e]					
Primary	25,000	25,000	20,000	20,000	20,000
Secondary	50,000	50,000	55,000	55,000	55,000
Total	75,000	75,000	75,000	75,000	75,000

See footnotes at end of table.

TABLE 14—Continued

LEAD: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010
Ireland, secondary[e]	22,000	22,500	22,500	19,000 [r]	20,000
Israel, secondary	25,000	25,000	27,000	22,000 [r, e]	25,000 [e]
Italy:					
Primary	34,600	45,000	47,800	15,000 [e]	15,000 [e]
Secondary	155,900	165,000	164,000	134,000 [e]	134,000 [e]
Total	190,500	210,000	211,800	149,000 [e]	149,000 [e]
Japan:					
Primary	108,271	104,527	107,005	96,974 [r]	98,000
Secondary	171,743 [r]	171,795	172,454	150,871 [r]	160,000
Total	280,014 [r]	276,322	279,459	247,845 [r]	258,000
Kazakhstan, primary and secondary	115,974	117,641	105,766 [r]	80,994 [r]	103,110
Kenya, secondary[e]	1,000	1,000	1,000	500 [r]	800
Korea, North, primary and secondary[e]	9,000	9,000	9,000	9,000	9,000
Korea, Republic of:					
Primary	163,379	195,022	244,137	222,461 [r]	200,000 [e]
Secondary[e]	56,000	60,000	60,000	60,000	60,000
Total	219,379	255,022	304,137	282,461 [r]	260,000 [e]
Malaysia, secondary[e, 5]	73,000	73,000	73,000	70,000	71,000
Mexico:					
Primary[6]	102,498	102,000 [e]	89,838	100,361	100,000
Secondary[e]	110,000	110,000	110,000	110,000	110,000
Total	212,498	212,000 [e]	199,838	210,361	210,000
Morocco:[e]					
Primary	38,000	45,000	45,000	45,000	45,000
Secondary	3,000	3,000	3,000	3,000	2,500
Total	41,000	48,000	48,000	48,000	47,500
Netherlands, secondary[e]	18,000	17,000	17,000	17,000	17,000
New Zealand, secondary[e]	7,000	7,000	9,000	13,000	9,000
Nigeria, secondary[e]	5,000	5,000	5,000	5,000	5,000
Pakistan, secondary[e]	3,100	3,000	3,000	2,900 [r]	2,900
Peru, primary	120,311	116,774	114,259	26,082 [r]	--
Philippines, secondary[e]	30,000	34,000 [r]	34,000 [r]	40,000 [r]	40,000
Poland:[e]					
Primary	26,200	37,200	38,000 [r]	30,000 [r]	35,000
Secondary	56,600	67,000	70,200 [r]	70,400 [r]	77,000
Total	82,800	104,000	108,000 [r]	100,000 [r]	112,000
Portugal, secondary[e]	3,000	3,000	3,000	3,000	3,000
Romania:[e]					
Primary	29,130 [r, 4]	34,368 [r, 4]	34,000	9,000 [r]	8,000
Secondary	5,000	5,000	5,000	5,000	3,000
Total	34,100	39,400 [r]	39,000	14,000 [r]	11,000
Russia, primary and secondary[e]	78,000	94,000	80,000	73,000	89,000
Saudi Arabia, secondary[e]	38,000	38,000	38,000	38,000	38,000
Serbia, primary and secondary	2,676 [r]	1,273 [r]	929 [r]	900 [r, e]	900 [e]
Slovenia, secondary[e]	15,000	15,000	15,000	14,000	14,000
South Africa, secondary	67,000	59,000	62,000	55,000 [e]	58,000 [e]
Spain, secondary	129,000 [r]	128,000 [r]	125,000 [r]	125,000 [r]	125,000 [e]

See footnotes at end of table.

TABLE 14—Continued

LEAD: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010
Sweden:[e]					
Primary	26,000	26,000	26,000	26,000	26,000
Secondary	40,000	40,000	40,000	40,000	35,000
Total	66,000	66,000	66,000	66,000	61,000
Switzerland, secondary[e]	9,600 [4]	9,000	8,000	8,000	8,000
Taiwan, secondary	55,000	55,000	55,000	40,000	35,000
Thailand, secondary	61,160	73,159	73,303	55,504 [r]	70,000 [e]
Tunisia, secondary[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Turkey, secondary[e]	6,000	6,000	6,000	6,000	6,000
Ukraine, secondary[e]	7,000 [r]	7,000 [r]	7,000 [r]	7,000 [r]	7,000
United Arab Emirates, secondary[e]	2,000	2,000	2,000	2,000	2,000
United Kingdom:					
Primary	174,700 [r]	119,000 [r]	139,000 [r]	135,000 [r]	150,000
Secondary	144,000	144,000 [r]	144,000	144,000	144,000
Total	318,700 [r]	263,000 [r]	283,000 [r]	279,000 [r]	294,000
United States:					
Primary	153,000	123,000	135,000	103,000	115,000
Secondary	1,160,000	1,180,000	1,140,000	1,110,000	1,140,000
Total	1,310,000	1,300,000	1,280,000	1,210,000	1,250,000
Venezuela, secondary[e]	30,000	30,000	30,000	30,000	30,000
Zambia, secondary[e]	1,000	1,000	1,000	1,000	1,000
Grand total	8,100,000 [r]	8,300,000 [r]	8,770,000 [r]	8,890,000 [r]	9,490,000
Of which:					
Primary	3,690,000 [r]	3,660,000 [r]	3,980,000 [r]	3,860,000 [r]	4,200,000
Secondary	4,200,000 [r]	4,420,000 [r]	4,600,000 [r]	4,860,000 [r]	5,090,000
Undifferentiated	206,000	222,000	196,000	164,000 [r]	202,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 7, 2011. Data included represent the total output of refined lead by each country, whether derived from ores and concentrates (primary) or scrap (secondary), and include the lead content of antimonial lead but exclude, to the extent possible, simple remelting of scrap.

[3] In addition to the countries listed, Colombia, Egypt, El Salvador, Iraq, and Trinidad and Tobago produced secondary lead, but output is not officially reported; available general information is inadequate for the formulation of reliable estimates of output levels.

[4] Reported figure.

[5] Metal Reclamation Industries' secondary lead smelter is receiving some primary mine concentrates from the Magellan Mine (Australia). The ore minerals are lead oxides and can be smelted at a secondary smelter.

[6] Includes lead content in antimonial lead.

LIME

By M. Michael Miller

Domestic survey data and tables were prepared by Shonta E. Osborne, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, the U.S. economy began a slow recovery from the longest recession since the 1930s. Increased consumption in steelmaking, chemical and industrial uses, and in flue gas desulfurization (FGD) led a surprisingly strong recovery in domestic lime production. In 2010, lime production increased by 2.5 million metric tons (Mt) (about 2.8 million short tons) and thus regained a large portion of the 4.1 Mt (4.5 million short tons) decrease reported for 2009. Lime sold and used in the United States totaled 18.3 Mt with a value of $1.92 billion (table 1).

The term lime as used throughout this chapter refers primarily to six chemicals produced by the calcination of high-purity calcitic or dolomitic limestone followed by hydration where necessary. There are two high-calcium forms—high-calcium quicklime (calcium oxide, CaO) and high-calcium hydrated lime [calcium hydroxide, $Ca(OH)_2$]. There are four dolomitic forms—dolomitic quicklime (CaO•MgO), dolomitic hydrate type N [$Ca(OH)_2$•MgO], dolomitic hydrate type S [$Ca(OH)_2$•$Mg(OH)_2$], and refractory dead-burned dolomite (CaO•MgO). Lime also can be produced from a variety of calcareous materials, such as aragonite, chalk, coral, marble, and shell. It also is regenerated (produced as a byproduct) by paper mills, carbide plants, and water-treatment plants. Regenerated lime, however, is beyond the scope of this report.

Legislation and Government Programs

The lime industry is a significant producer of greenhouse gases, primarily in the form of carbon dioxide generated from the calcination of limestone and from fuels burned to achieve calcination. In May, the U.S. Environmental Protection Agency (EPA) issued a final rule that addresses greenhouse gas (GHG) emissions from stationary sources under the Clean Air Act (CAA) permitting programs. This final rule sets thresholds for GHG emissions that define when permits under the New Source Review Prevention of Significant Deterioration (PSD) and CAA Title V Operating Permit programs are required for new and existing industrial facilities. This final rule "tailors" the requirements of these CAA permitting programs to facilities responsible for nearly 70% of national GHG emissions from stationary sources. Beginning in January 2011, facilities already subject to PSD permitting that wish to construct a new facility or modify an existing facility with expected GHG emissions above 75,000 short tons per year (on a carbon dioxide equivalent basis) would be subject to GHG permitting requirements under PSD, and they would need to determine the best available control technology (BACT) for their GHG emissions. This rule would apply to the Nation's largest GHG emitters, such as cement plants, powerplants, and refineries, as well as lime plants (U.S. Environmental Protection Agency, 2010b).

In November, the EPA published GHG BACT guidance, where BACT was defined as an emissions limitation based on the maximum degree of reduction for GHGs that would be emitted from any proposed major stationary source or major modification of an existing source. In the BACT review, permitting agencies must identify available control technologies, eliminate those that are technically impractical, rank remaining controls based on environmental effectiveness, and evaluate cost effectiveness of controls and energy and environmental impacts (U.S. Environmental Protection Agency, 2010a).

Production

Domestic production data for lime were derived by the U.S. Geological Survey (USGS) from a voluntary survey of U.S. operations. The survey was sent to primary producers of quicklime and hydrate, but in order to avoid double counting, it was not sent to independent hydrators that purchase quicklime for hydration. Quantity data were collected for 28 specific and general end uses, and value data were collected by type of lime, such as high-calcium or dolomitic. Because value data were not collected by end use, value data listed in table 3 were determined by calculating the average value per metric ton of lime sold or used for each respondent and then multiplying that figure by the quantity of lime that the respondent reported sold or used for each end use. Table 3 lists the total quantity sold or used for an end use and the total value of the quicklime and hydrate sold or used for that end use calculated as described above. A similar methodology using average hydrate values was used to calculate the value of hydrate sold and used listed in table 4.

In 2010, of the 85 operations that were canvassed, responses were received for 75 plants, representing 96% of the total sold or used by producers. Production data for the nonrespondents were estimated based on prior-year production figures and other information or were included with data reported for other operations.

Lime is a basic chemical that was produced as quicklime in 29 States and Puerto Rico. During 2010, quicklime was produced at 76 lime plants, and included 32 plants with collocated hydrating plants. Hydrated lime also was produced at 15 standalone hydrating facilities, including 3 plants where the kilns had been shut down and hydrate was manufactured from quicklime produced offsite. These numbers do not necessarily agree with the number of plants reported in tables 1 and 2 because, for data collection purposes, some company operations have been combined at the respondent's request. In a few States with no quicklime production, hydrating plants used quicklime shipped from other States. There were also a small number of slurry plants where lime was converted to liquid form by the addition of water prior to sale; this is sometimes called milk-of-lime.

In addition to stationary slurry plants, there were mobile hot lime slurry production systems designed to slake quicklime or slurry hydrated lime to the percent solids required for each job. States with production exceeding 2 Mt were, in descending order, Missouri and Alabama; States with production between 1 and 2 Mt were, in descending order, Kentucky, Ohio, Texas, Pennsylvania, and Nevada.

Total lime sold or used by domestic producers in 2010 was 18.3 Mt, an increase of 2.5 Mt or about 16% compared with that of 2009. Production included the commercial sale or captive consumption (described by the term "used") of quicklime, hydrated lime, and dead-burned refractory dolomite. Data were incomplete on production of hydrated lime because some producers do not report data on downstream hydrating plants. Traditionally, most U.S. lime production sold and used is in the form of high-calcium quicklime. In 2010, the production of high-calcium quicklime increased by nearly 17% to 13.8 Mt (15.2 million short tons), and accounted for 75% of total production. The production of high-calcium hydrate increased by 13%. Production of dolomitic quicklime increased by 15%, but production of dolomitic hydrate continued to be adversely affected by the depressed housing and construction markets and decreased by 8%. Commercial sales increased to 16.9 Mt (18.6 million short tons), and captive consumption increased to 1.37 Mt (1.51 million short tons).

In 2010, there were only minor company changes in the U.S. lime industry. Chemical Lime Co. (Fort Worth, TX) changed its name to Lhoist North America to more closely align its North American operations with its parent, the Lhoist Group (Brussels, Belgium). Missouri Lime LLC (Bonne Terre, MO) was sold in the fall and was in the process of changing its name to Valley Minerals LLC.

Although the lime industry reported significant production increases at many plants, a number of the plants idled in 2009 remained shut down during 2010. These included three Lhoist North America plants (Douglas, AZ; Tenmile, ID; and Grantsville, UT) and two Carmeuse Lime & Stone plants (South Chicago, IL; and Winchester, VA).

At yearend, the top 10 companies were, in descending order of U.S. lime production, Carmeuse, Lhoist, Graymont Ltd., Mississippi Lime Co., United States Lime & Minerals, Inc., Western Lime Corp., Martin Marietta Magnesia Specialties LLC, Southern Lime Co., ArcelorMittal USA Inc., and American Crystal Sugar Co. These companies reported production from 45 lime plants and 12 separate hydrating plants and accounted for nearly 91% of the combined commercial lime sales and 88% of total lime production.

Consumption

In 2010, the U.S. economy was recovering from the longest recession since the Great Depression of the 1930s, and lime consumption reflected the Nation's economic recovery—strong in some sectors while lagging in others. The approximate breakdown of lime consumption by general end-use sectors was as follows: 35% for metallurgical uses, 32% for environmental uses, 23% for chemical and industrial uses, 9% for construction uses, and 1% for refractory dolomite (table 3). These end-use data were based on lime sold and used by domestic producers and do not include lime imports. Consumption for metallurgical uses, which had accounted for 57% of the overall decrease in lime consumption in 2009, recorded the most significant gains in 2010, increasing by 1.55 Mt and accounting for 62% of the overall increase in lime consumption. Other market sectors recorded significant but much smaller increases—environmental [501,000 metric tons (t)], chemical and industrial (287,000 t), and construction (127,000 t).

Commercial sales accounted for 92% of domestic production. Captive lime accounted for the remainder of domestic production and was used mainly in the production of steel in basic oxygen furnaces (BOF), sugar refining, magnesia production, and refractories. Almost all data on captive lime production are withheld to avoid disclosing company proprietary information. As a result, table 3 lists the total quantity and value of lime by end use. End uses with captive production are listed in footnote 4 of the table.

In steel refining, quicklime is used as a flux to remove impurities, such as phosphorus, silica, and sulfur. The steel industry accounted for 29% of lime sold by domestic lime companies and the lime produced and used by ArcelorMittal USA from its captive lime plant. In 2009, U.S. steel production decreased by 36% (33.2 Mt) compared with that of 2008, and raw steel capacity utilization at U.S. steel mills averaged only 51% for the year. In 2010, demand picked up significantly and steel production increased by 38% (22.4 Mt) to 80.6 Mt and raw steel capacity utilization averaged 70% (Fenton, 2011; World Steel Association, undated). In 2010, lime consumption from domestic sources for steelmaking and related uses was 5.3 Mt, an increase of 39% compared with that of 2009.

In nonferrous metallurgy, lime is used in the beneficiation of copper ores to neutralize the acidic effects of pyrite and other iron sulfides and to maintain the proper pH in the flotation process. Lime is used to process alumina and magnesia, to extract uranium from gold slimes, to recover nickel by precipitation, and to control the pH of the sodium cyanide solution used to leach gold and silver from the ore. Gold and silver are recovered using heap leaching and by conventional milling and subsequent leaching of the slurry. The sodium cyanide solution dissolves gold from the ore and forms a stable gold-cyanide complex, and the gold can then be separated through the use of highly activated carbon. Heap leaching involves crushing the ore, mixing it with lime for pH control and agglomeration, and stacking the ore in heaps on specially prepared pads for treatment with cyanide solution. Lime is used to maintain the pH of the cyanide solution at a level between 10 and 11 to maximize the recovery of precious metals and to prevent the creation of hydrogen cyanide. Lime consumption data for these various uses (aluminum and bauxite processing, concentration of copper and gold ores, and unspecified nonferrous uses) are combined to avoid disclosing company proprietary data and are reported in table 3 under metallurgical, nonferrous metallurgy. In 2010, lime consumption in nonferrous metallurgy increased by about 5% to 1.13 Mt, but this was only a modest recovery from the 21% decrease recorded in 2009. Although specific data are not collected on lime consumption for copper recovery or for gold recovery, the increase in nonferrous lime consumption was likely the result of the increase in gold production of about 7% compared with that of 2009 (George, 2011). Copper flotation concentrate production, in comparison, decreased by about 4% in 2010. Mine production of copper was at its lowest level since 1985 owing to lower ore grades and production cutbacks announced following the sharp fall in copper prices at yearend 2008 (Edelstein, 2011).

Environmental remediation uses of lime in mining include treatment of the tailings that result from the recovery of precious metals, such as gold and silver. These tailings may contain elevated levels of cyanides, and lime is used to recover cyanides in such treatment processes as alkaline chlorination, Caro's acid (H_2SO_5), Cyanisorb™, and sulfur dioxide/air.

Lime is used, generally in conjunction with soda ash, for softening municipal and plant process water. This precipitation process removes bivalent soluble calcium and magnesium cations (and to a lesser extent, ferrous iron, manganese, strontium, and zinc) that contribute to the hardness of water. This process also reduces carbonate alkalinity and total dissolved solids. Lime consumption for drinking water treatment decreased by about 5% compared with that of 2009.

In sewage treatment, the traditional role of lime is to control pH in the sludge digester, which removes dissolved and suspended solids that contain phosphates and nitrogen compounds. Lime also aids in clarification and in destroying harmful bacteria. The leading use in sewage treatment is to stabilize the resulting sewage sludge. Sewage sludge stabilization, also called biosolids stabilization, reduces odors, pathogens, and putrescibility of the solids. Lime stabilization involves mixing quicklime with the sludge to raise the temperature and pH of the sludge to minimum levels for a specified period of time. In 2010, lime consumption for all sludge treatment increased by nearly 17% compared with that of 2009.

In FGD systems serving coal-fired powerplants, incinerators (most are waste-to-energy powerplants), and industrial plants, lime is injected into the flue gas to remove acidic gases, particularly sulfur dioxide (SO_2) and hydrochloric acid (HCl). It also may be used to stabilize the resulting sludge before disposal. Many FGD systems at utility powerplants are now designed to produce byproduct gypsum from the SO_2 emissions. This byproduct material is suitable for use in manufacturing gypsum wallboard, as an additive in portland cement, and as a soil amendment in agriculture. Hydrated lime may be used in another FGD-related market—to control sulfur trioxide (SO_3) emissions from selective catalytic reduction (SCR) systems installed at powerplants to control emissions of nitrogen oxides (NOx). Utility powerplants were by far the largest consumers of lime for FGD and accounted for 92% of the total FGD lime market in 2010. Incinerators, industrial boilers, and other FGD uses accounted for the remaining 8%. The FGD market benefitted from increased coal consumption for electricity generation as a result of the unusually long, hot summer experienced in the East and South. In 2010, lime consumption in all FGD markets increased by 421,000 t, but most of the increase was in the utility powerplants sector. The trend toward greater use of hydrated lime to treat SO_3 emissions from SCR systems at utility powerplants continued with consumption increasing by 39% compared with that of 2009.

Lime is used by the pulp and paper industry in the basic Kraft pulping process where wood chips and an aqueous solution (called liquor) of sodium hydroxide and sodium sulfide are heated in a digester. The cooked wood chips (pulp) are discharged under pressure along with the spent liquor. The pulp is screened, washed, and sent directly either to the paper machine or to the bleaching plant. Lime is sometimes used to produce calcium hypochlorite bleach for bleaching the paper pulp. The spent liquor is processed through a recovery furnace, where dissolved organics are burned to recover waste heat, sodium sulfide, and sodium carbonate. The recovered sodium sulfide and sodium carbonate are diluted with water and then treated with slaked lime to recausticize the sodium carbonate into sodium hydroxide (caustic soda) for reuse. The byproduct calcium carbonate is recalcined in a lime kiln to recover lime for reuse. The paper industry also uses lime as a coagulant aid in the clarification of plant process water. In 2010, consumption for pulp and paper production increased by about 4% compared with that of 2009.

Lime is used to make precipitated calcium carbonate (PCC), a specialty filler used in premium-quality coated and uncoated papers, paint, and plastics. The most common PCC production process used in the United States is the carbonation process. CO_2 is bubbled through milk-of-lime to form a precipitate of calcium carbonate and water. The reaction conditions determine the size and shape of the resulting PCC crystals. Lime used for PCC production increased by nearly 7% compared with that of 2009.

The chemical industry uses lime in the manufacture of alkalis. Quicklime is combined with coke to produce calcium carbide, which is used to make acetylene and calcium cyanide. Lime is used to make calcium hypochlorite, citric acid, petrochemicals, and other chemicals.

In sugar refining, milk-of-lime is used to raise the pH of the product stream, precipitating colloidal impurities. The lime itself is then removed by reaction with CO_2 to precipitate calcium carbonate.

In road paving, hydrated lime is used in hot mix asphalt to act as an antistripping agent. Stripping is generally defined as a loss of adhesion between the aggregate surface and the asphalt cement binder in the presence of moisture. Lime also is used in cold in-place recycling for the rehabilitation of distressed asphalt pavements. Existing asphalt pavement is pulverized using a milling machine, and a hot lime slurry is added along with asphalt emulsion. The cold recycled mix is placed and compacted by conventional paving equipment, which produces a smooth base course for the new asphalt surface. In 2010, sales of lime for use in asphalt increased for the second year in a row and were up by nearly 6% compared with those for 2009, but the 297,000 t sold was still 16% below the quantity sold in 2007.

In construction, hydrated lime and quicklime are used to stabilize fine-grained soils in place of materials that are employed as subbases, such as hydraulic clay fills or otherwise poor-quality clay and silty materials obtained from cuts or borrow pits. Lime also is used in base stabilization, which includes upgrading the strength and consistency properties of aggregates that may be judged unusable or marginal without stabilization. Common applications for lime stabilization included the construction of airfields, building foundations, earthen dams, parking areas, and roads.

Lime sales for soil stabilization tend to be cyclical, especially in large market areas, such as Texas. In soil stabilization, lime competes with cement, cement kiln dust, fly ash, and other additives (liquid enzymes, for example). Choices made by consumers can depend on availability, price, contract specifications, soil chemistry, and State and Federal funding in the case of highway construction projects. In 2010, the soil stabilization market continued to be adversely affected by the slow recovery from the recession and by reduced highway spending at the State level, although some additional Federal funding would have been available from the American Recovery and Reinvestment Act of 2009, which was signed into law in February 2009. Primarily as a result of increased demand for a small number of specific projects, lime sold for soil stabilization increased to 983,000 t or by 16% compared with that of 2009. This was, however, still 30% less than the quantity sold for stabilization in 2008 (1.41 Mt) and 36% less than that of 2007 (1.54 Mt).

Hydrated lime is used in the traditional building sector in mortars, plaster, and stucco. Standard cement mortars that include lime exhibit superior workability balanced with appropriate compressive strength, as well as low water permeability and superior bond strength. Lime is a major constituent in exterior and interior plasters and stuccos, enhancing the durability, strength, and workability of these finishes. A small amount of hydrated lime also is used in the renovation of old structures built with lime mortars, which was standard before the development of portland cement mortars. Modern portland cement mortars are incompatible with old lime mortars. Hydrated lime also is used to make synthetic hydraulic lime, which is produced by blending powdered hydrated lime with pulverized pozzolanic or hydraulic materials.

The U.S. Census Bureau collects data on construction spending for residential construction and 16 categories of nonresidential construction. Although the annual value of residential construction decreased only slightly, the annual value of nonresidential construction decreased by 14% compared with that of 2009 (U.S. Census Bureau, 2011). Nearly all lime sold for traditional building uses is in the form of hydrate; in 2010, sales of hydrated lime for traditional building uses decreased by 11% compared with those of 2009. Most of the lime sold for building uses was produced at a handful of plants located in Nevada, Ohio, Texas, and Wisconsin.

Dead-burned dolomite, also called refractory lime, is used as a component in tar-bonded refractory brick or monolithics manufactured for use in BOF. Refractory brick also is used in the lining of many treatment and casting ladles, in argon oxygen decarburization and vacuum oxygen decarburization converters, in electric arc furnaces (EAF), and in continuous steel casting. Although the data reported in this chapter were rounded to one significant figure to avoid disclosing company proprietary data, the production of dead-burned dolomite increased by 20% compared with that of 2009. Magnesita Refractories Co. (formerly LWB Refractories Co.) at its York, PA, plant and Carmeuse at its Millersville, OH, plant were the only significant producers. Although dead-burned dolomite is the primary form of lime used in refractories, hydrated lime may be used to produce silica refractory brick used to line industrial furnaces.

Prices

The average values per ton for the various types of lime are listed in table 5. All value data for lime are reported by type of lime produced—high-calcium quicklime, high-calcium hydrate, dolomitic quicklime, and dolomitic hydrate. To avoid revealing company proprietary data, value data for dead-burned dolomite are included with the averages for all types.

Lime prices stabilized in 2010 after moderate annual increases in recent years and the large increase recorded in 2009. The following average values are compared with those of 2009. The average value for all types of lime sold increased slightly to $104.30 per metric ton ($94.60 per short ton). The average value for high-calcium quicklime sold increased by $2.40 per ton to $100.60 per ton ($91.30 per short ton). Reflecting increased supplies in the Midwest from plants that were idle all or part of 2009, the average value for dolomitic quicklime sold decreased by nearly 7% to $104.30 per ton ($94.60 per short ton). The average value of high-calcium hydrate decreased slightly, while the average value of dolomitic hydrate increased slightly.

Foreign Trade

The United States exported and imported calcined dolomite (dolomitic lime), hydrated lime (slaked lime), hydraulic lime, and quicklime. Combined exports of lime were 215,000 t (237,000 short tons) valued at $36.2 million. About 88% of exports went to Canada, with the bulk of the remaining exports going to Russia (6%) and Mexico (4%) (table 6).

Combined imports of lime were 445,000 t (491,000 short tons) valued at $61.5 million, with 90% from Canada, 9% from Mexico, and 1% from other countries (table 7). Canada was the primary import source of high-calcium quicklime and accounted for 98% of the total. Imports of dolomitic quicklime came almost exclusively from Canada (68%) and Mexico (31%), as was the case for hydrated lime Canada (58%) and Mexico (40%).

No tariffs are placed on imports of hydraulic lime, quicklime, and slaked lime from countries with normal trade relations (NTR) with the United States. A 3% ad valorem tariff is placed on imports of calcined dolomite from NTR countries.

World Review

There is only limited international trade in lime. Traditionally, lime has been a low-value bulk product that could not be shipped long distances and compete with lime produced locally. Most countries have limestone or dolomite deposits and as a result are able to manufacture lime for their own consumption. There may be some trade between countries on a regional basis where distances are not too great, such as in the European Union, or to supply lime products of quality not locally available.

With the exception of some industrialized nations, accurate lime production data for individual countries are difficult to obtain. Besides production by large commercial lime companies, lime is produced by small-scale manufacturers operating simple kilns to supply individual villages and by industries producing lime for captive consumption. These variations and the frequent confusion with limestone data make accurate reporting extremely difficult and certainly incomplete. In some cases, lime sales data have been used to estimate country production figures. Beginning in 2006, major revisions were made to the estimates for China based on new information. Beginning in 2009, major revisions were made to estimates for India, based on steel production and other market assumptions (table 8).

Outlook

Although insulated from some of the effects of economic downturns by having diverse markets, the U.S. lime industry experienced lost sales in most markets owing to the severity of the 2008–09 recession. Steelmaking remains the leading market for lime, and the slowly recovering economy has seen a rebound in domestic steel production, but it still is significantly below prerecession levels. U.S. steel production is expected to exhibit a modest increase in 2011, with greater growth expected in 2012. Lime sales for steelmaking are expected to follow suit.

FGD is the second leading end-use market for lime. With the economy recovering, albeit slowly, electric power generation rates are expected to increase, and lime consumption for FGD also is expected to increase. Long-term growth is still expected in the FGD and related markets as a result of EPA's replacing the clean air interstate rule (CAIR). CAIR was vacated in July 2008 by the Circuit Court for the District of Columbia Court of Appeals but was revived when the court agreed with the EPA that the effect of vacating the CAIR was detrimental to the environment. The EPA was instructed, however, to revise or replace the CAIR in order to fix major flaws. In July 2010, the EPA proposed a rule known as the clean air transport rule (CATR) that would require 31 States and the District of Columbia to significantly improve air quality by reducing powerplant emissions that contribute to ozone and fine particle pollution in other States. Specific to the FGD market, 28 States would be required to reduce annual SO_2 and NOx emissions. The final rule was expected in midyear 2011 and would go into effect 1 year after passage of the final rule, although a delay to allow utilities more time to comply was being proposed by industry.

The CATR may have mixed results with respect to lime consumption for FGD. Utilities may install additional FGD controls but also may choose to switch fuels from coal to cleaner burning natural gas and to retire older plants and replace them with natural-gas-fired plants. Fuel switching makes economic sense, especially if natural gas prices stay within a range of \$4 to \$7 per million British thermal units (Btu). By comparison, coal prices in 2010 suggested an estimated coal cost for powerplants of \$4.75 per million Btu. There is already evidence of a shift from the use of coal to natural gas in the utility market. In 2010, coal accounted for an estimated 47% of electricity generated compared with 51% in 2005. In 2010, natural gas' share was an estimated 23% compared with 17% in 2005 (Zhou, 2010).

The nonferrous metallurgy market for lime is expected to benefit from increased U.S. mine production of copper in 2011, following restoration of production at curtailed operations.

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TABLE 1
SALIENT LIME STATISTICS[1, 2]

		2006	2007	2008	2009	2010
United States[3]						
Number of plants[4]		91	89	90	81 r	85
Sold or used by producers:						
Quicklime:						
High-calcium	thousand metric tons	15,000	14,700	14,900	11,800	13,800
Dolomitic	do.	2,950	2,700	2,310	1,830	2,110
Total	do.	18,000	17,400	17,200	13,600 r	15,900
Hydrated lime:						
High-calcium	do.	2,370	2,240	2,070	1,690	1,910
Dolomitic	do.	409	352	358	261	239
Total	do.	2,780	2,590	2,420	1,950	2,150
Dead-burned dolomite[5]	do.	200	200	200	200	200
Grand total:						
Quantity	do.	21,000	20,200	19,900	15,800	18,300
Value[6]	thousand dollars	1,700,000	1,760,000	1,840,000	1,660,000	1,920,000
Average value	dollars per metric ton	81.20	87.10	92.40	105.02	105.35
Lime sold by producers:						
Quicklime	thousand metric tons	16,600	16,100	16,000	12,600	14,700
Hydrated lime	do.	2,780	2,590	2,420	1,950	2,140
Total	do.	19,400	18,700	18,400	14,500	16,900
Value	thousand dollars	1,560,000	1,600,000	1,690,000	1,510,000	1,760,000
Lime used by producers	thousand metric tons	1,620	1,530	1,470	1,260	1,370
Value	thousand dollars	144,000	155,000	149,000	147,000 r	161,000
Exports:[7]						
Quantity	do.	116	144	174	108	215
Value	do.	19,200	24,800	27,100	18,500	36,200
Imports for consumption:[7]						
Quantity	thousand metric tons	298	375	307	422	445
Value	thousand dollars	36,300	49,600	39,400	53,200	61,500
Consumption, apparent[8]	thousand metric tons	21,200	20,400	20,000	16,100	18,500
World, production	do.	285,000 r	296,000	307,000	297,000 r	311,000 e

eEstimated. rRevised. do. Ditto.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] To convert metric tons to short tons, multiply metric tons by 1.102.

[3] Excludes regenerated lime; includes Puerto Rico.

[4] Includes most producer-owned hydrating plants not located at lime plants.

[5] Data are rounded to no more than one significant digit to avoid disclosing company proprietary data.

[6] Selling value, free on board plant.

[7] Source: U.S. Census Bureau.

[8] Defined as sold or used plus imports minus exports.

TABLE 2

LIME SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE [1, 2]

State	Plants[3]	Hydrated (thousand metric tons)[4]	Quicklime[5] (thousand metric tons)[4]	Total (thousand metric tons)[4]	Value (thousands)
2009:					
Alabama	6	114	1,840	1,960	$226,000[r]
Arizona, Colorado, Montana, Nevada, Utah, Wyoming	13	193[r]	2,210[r]	2,410[r]	246,000[r]
California, Idaho, Oregon, Washington	9	48[r]	213[r]	260[r]	38,000[r]
Indiana, Missouri	4	371	2,530[r]	2,900[r]	295,000[r]
Iowa, Nebraska, South Dakota	3	(6)	298	298	29,500
Kentucky, Tennessee, West Virginia	6	103[r]	2,240[r]	2,340[r]	208,000[r]
Ohio	5	85	1,040	1,130	129,000
Pennsylvania	4	167	818	985	126,000
Texas	5	454[r]	590	1,040	105,000
Wisconsin	4	145	606	751	70,000[r]
Other[7]	22[r]	233[r]	1,470	1,710	184,000
Total	81[r]	1,910	13,900	15,800	1,660,000
2010:					
Alabama	6	153	2,000	2,150	239,000
Arizona, Colorado, Montana, Nevada, New Mexico, Utah, Wyoming	14	189	2,330	2,510	274,000
California, Idaho, Oregon, Washington	9	52	212	264	39,700
Indiana, Missouri	5	401	3,140	3,540	361,000
Iowa, Nebraska, South Dakota	3	(6)	354	354	35,700
Kentucky, Tennessee, West Virginia	6	112	2,490	2,600	235,000
Ohio	5	79	1,530	1,610	164,000
Pennsylvania	4	179	926	1,110	145,000
Texas	5	553	730	1,280	136,000
Wisconsin	4	150	716	866	81,200
Other[7]	24	236	1,740	1,980	215,000
Total	85	2,100	16,200	18,300	1,920,000

[r] Revised.

[1] Excludes regenerated lime.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Includes most producer-owned hydrating plants not located at lime plants.

[4] To convert metric tons to short tons, multiply metric tons by 1.102.

[5] Includes dead-burned dolomite.

[6] Withheld to avoid disclosing company proprietary data; included in "Quicklime."

[7] Includes Arkansas, Florida, Georgia, Louisiana, Massachusetts, Michigan, Minnesota, North Dakota, Oklahoma, Puerto Rico, and Virginia.

TABLE 3

LIME SOLD AND USED BY PRODUCERS IN THE UNITED STATES, BY USE[1, 2]

(Thousand metric tons[3] and thousand dollars)

Use	2009		2010	
	Quantity[4]	Value[r, 5]	Quantity[4]	Value[5]
Chemical and industrial:				
Fertilizer, aglime and fertilizer	52	5,460	52	5,480
Glass	106	11,100	181	19,100
Paper and pulp	814	85,500	843	88,800
Precipitated calcium carbonate	944	99,100	1,010	106,000
Sugar refining	731 [r]	76,800	671	70,700
Other chemical and industrial[6]	1,240	130,000	1,420	149,000
Total	3,890	408,000	4,170	440,000
Metallurgical:				
Steel and iron:				
Basic oxygen furnaces	1,690 [r]	178,000	2,430	256,000
Electric arc furnaces	2,000 [r]	210,000	2,670	281,000
Other steel and iron	121 [r]	12,700	212	22,300
Total	3,810	400,000	5,310	559,000
Nonferrous metallurgy[7]	1,080	114,000	1,130	119,000
Total metallurgical	4,900	514,000	6,440	679,000
Construction:				
Asphalt	281	29,500	297	31,300
Building uses	254	26,700	230	24,200
Soil stabilization	848	89,100	983	104,000
Other construction	39	4,100	39	4,110
Total	1,420	149,000	1,550	163,000
Environmental:				
Flue gas desulfurization (FGD):				
Utility powerplants	3,110	327,000	3,520	371,000
Incinerators	216	22,700	227	23,900
Industrial boilers and other FGD	64 [r]	6,720	70	7,380
Total	3,390 [r]	356,000	3,820	402,000
Sludge treatment:				
Sewage	86	9,030	110	11,600
Other, industrial and hazardous	81	8,510	85	8,960
Total	167	17,500	195	20,500
Water treatment:				
Acid-mine drainage	82	8,610	90	9,480
Drinking water	963	101,000	911	96,000
Wastewater	630	66,200	649	68,400
Total	1,680	176,000	1,650	174,000
Other environmental	149 [r]	15,600	226	23,800
Total environmental	5,390	367,000	5,890	620,000
Refractories (dead-burned dolomite)	200 [8]	18,700 [9]	200 [8]	22,500 [9]
Grand total	15,800	1,660,000	18,300	1,920,000

[r] Revised.

[1] Excludes regenerated lime. Includes Puerto Rico.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] To convert metric tons to short tons, multiply metric tons by 1.102.

[4] Quantity includes lime sold and used, where "used" denotes lime produced for internal company use for basic oxygen furnaces, magnesia, paper and pulp, precipitated calcium carbonate, refractories, and sugar refining.

[5] The U.S. Geological Survey does not collect value data by end use; the values shown are derived from average lime values.

[6] May include alkalis, calcium carbide and cyanamide, calcium hypochlorite, citric acid, food (animal or human), oil and grease, oil well drilling, petrochemicals, tanning, and other uses. Magnesia is included here to avoid disclosing proprietary data.

[7] Includes aluminum and bauxite, magnesium, ore concentration (copper and gold), and other nonferrous uses.

[8] Data are rounded to no more than one significant digit to avoid disclosing company proprietary data.

TABLE 3—Continued
LIME SOLD AND USED BY PRODUCERS IN THE UNITED STATES, BY USE[1,2]

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[9] Value was derived from an average lime value per metric ton rather than a specific average value per metric ton of dead-burned dolomite.

TABLE 4
HYDRATED LIME SOLD OR USED IN THE UNITED STATES, BY END USE[1,2]

(Thousand metric tons[3] and thousand dollars)

	2009		2010	
Use	Quantity[4]	Value[5]	Quantity[4]	Value[5]
Chemical and industrial	482	60,900 r	539	67,200
Construction:				
Asphalt	251	31,700	262	32,700
Building uses	248	31,300 r	220	27,400
Soil stabilization	310	39,200 r	378	47,100
Other construction	12	1,520 r	10	1,250
Total	821	104,000 r	870	108,000
Environmental:				
Flue gas desulfurization (FGD):				
Utility powerplants	113	14,300	157	19,600
Incinerators	31	3,920 r	31	3,860
Industrial boilers and other FGD	19	2,400 r	23	2,870
Total	163	20,600 r	211	26,300
Sludge treatment:				
Sewage	16	2,020 r	16	1,990
Other sludge treatment	28	3,540 r	30	3,740
Total	44	5,560 r	46	5,730
Water treatment:				
Acid-mine drainage	46	5,810 r	45	5,610
Drinking water	138	17,400 r	140	17,500
Wastewater	193	24,400 r	186	23,200
Total	377	47,600 r	371	46,200
Other environmental	38	4,800 r	72	8,970
Metallurgy	30	3,790 r	43	5,360
Grand total	1,950	247,000 r	2,150	268,000

[r] Revised.

[1] Excludes regenerated lime. Includes Puerto Rico.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] To convert metric tons to short tons, multiply metric tons by 1.102.

[4] Quantity includes hydrated lime sold and used, where "used" denotes lime produced for internal company use in building, chemical and industrial, and metallurgical sectors.

[5] The U.S. Geological Survey does not collect value data by end use; the values shown are derived from an average value per metric ton of hydrated lime.

TABLE 5
LIME PRICES[1]

Type	2009 Dollars per metric ton	2009 Dollars per short ton[2]	2010 Dollars per metric ton	2010 Dollars per short ton[2]
Sold and used:				
Quicklime	102.00	92.50	102.70	93.20
Hydrate	126.40	114.70	125.00	113.40
Average all types[3]	105.00	95.30 r	105.40	95.60
Sold:				
High-calcium quicklime	98.20	89.10	100.60	91.20
Dolomitic quicklime	111.90	101.50	104.30	94.60
Average quicklime	100.00	90.70	101.00	91.70
High-calcium hydrate	124.60	113.00	122.70	111.30
Dolomitic hydrate	138.20	125.30	139.30	126.60
Average hydrate	126.40	114.70	124.60	113.00
Average all types[3]	103.80	94.20	104.30	94.60

rRevised.

[1] Average value per ton, on a free-on-board-plant basis, including cost of containers.

[2] Unit values in metric and short tons were rounded independently.

[3] Includes dead-burned dolomite.

TABLE 6
U.S. EXPORTS OF LIME, BY TYPE[1]

(Metric tons and dollars)

Type	2009 Quantity[2]	2009 Value[3]	2010 Quantity[2]	2010 Value[3]
Calcined dolomite:				
Canada	43,100	7,200,000	57,300	10,000,000
Germany	--	--	1,080	295,000
Colombia	3	2,850	317	108,000
Mexico	267	66,800	34	7,570
Other	100 r	49,000 r	296	136,000
Total	43,400	7,320,000	59,100	10,600,000
Hydraulic lime:				
Austria	667	120,000	--	--
Bahamas, The	209	56,900	123	30,100
Canada	4,880	916,000	3,640	757,000
Other	338 r	151,000 r	165	411,000
Total	6,090	1,240,000	3,930	1,200,000
Quicklime:				
Canada	34,200	5,610,000	109,000	14,900,000
Costa Rica	477	150,000	662	212,000
Mexico	9,710	1,030,000	8,490	982,000
Russia	--	--	13,400	3,000,000
Other	151	319,000	675	805,000
Total	44,500	7,100,000	132,000	19,900,000
Slaked lime, hydrate:				
Angola	18	4,980	884	505,000
Canada	13,600	2,620,000	18,300	3,550,000
Nigeria	449	122,000	304	127,000
Other	42	72,600	373	356,000
Total	14,100	2,820,000	19,900	4,540,000
Grand total	108,000	18,500,000	215,000	36,200,000

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] To convert metric tons to short tons, multiply metric tons by 1.102.

[3] Declared free alongside ship valuation.

Source: U.S. Census Bureau.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF LIME, BY TYPE[1]

(Metric tons and dollars)

Type	2009 Quantity[2]	2009 Value[3]	2010 Quantity[2]	2010 Value[3]
Calcined dolomite:				
Canada	7,740	1,200,000	29,600	4,580,000
Mexico	33,000	2,520,000	13,200	4,470,000
Other	8	13,800	409	292,000
Total	40,700	3,730,000	43,200	9,340,000
Hydraulic lime:				
Canada	53	10,900	31	3,770
France	181	113,000	240	127,000
Mexico	61	7,520	--	--
Netherlands	72	25,500	--	--
Other	56	27,800	43	23,900
Total	423	185,000	314	155,000
Quicklime:				
Canada	322,000	40,100,000	340,000	42,400,000
Colombia	3	371,000	2,010	255,000
Mexico	5,070	553,000	4,680	569,000
Other	1,180	310,000 [r]	873	482,000
Total	329,000	41,300,000	348,000	43,700,000
Slaked lime, hydrate:				
Canada	29,200	3,680,000	31,500	4,250,000
Mexico	22,100	3,210,000	21,700	3,410,000
Other	1,100	1,070,000	909	728,000
Total	52,300	7,960,000	54,000	8,390,000
Grand total	422,000	53,200,000	445,000	61,500,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] To convert metric tons to short tons, multiply metric tons by 1.102.

[3] Declared cost, insurance, and freight valuation.

Source: U.S. Census Bureau.

TABLE 8
QUICKLIME AND HYDRATED LIME, INCLUDING DEAD-BURNED DOLOMITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Australia[e]	1,600	1,600	2,200	2,000	2,000
Austria	465	491	612	507 [r]	500
Belgium[e, 4]	2,400	2,400	2,300	2,000	2,000
Bosnia and Herzegovina	218	237	216	281 [r]	280
Brazil[e]	7,057 [5]	7,393 [5]	7,400	7,450	7,700
Bulgaria[4]	1,409	1,443	1,422 [r]	950 [r]	1,000
Canada	2,185	2,134	2,069	1,601	1,910
Chile[e]	820 [r]	840 [r]	820 [r]	790 [r]	800
China[e]	160,000	170,000	180,000	185,000	190,000
Croatia[e, 4]	260 [5]	572 [5]	541 [r]	415 [r]	415
Czech Republic	1,218	1,277	1,150 [r]	1,000 [r]	1,100
Egypt[e]	800	1,000 [5]	1,000 [5]	800 [r]	800
Finland[e]	430	517 [5]	482 [5]	500	475
France[e, 4]	4,000	4,000	4,000	3,500	3,500
Germany	7,119	7,218	7,313	5,830 [r]	6,850

See footnotes at end of table.

TABLE 8—Continued

QUICKLIME AND HYDRATED LIME, INCLUDING DEAD-BURNED DOLOMITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Hungary[e]	500	500	500	500	500
India[e]	12,000	12,000	13,000	13,000	14,000
Iran[e]	2,600	2,600	2,700	2,700	2,700
Israel	158	282	481	429 [r]	430
Italy[e, 6]	5,900	6,000	6,000	6,000	6,000
Jamaica	304	277	313	300	300
Japan, quicklime only	9,014	9,359	9,528	6,746 [r]	7,200
Kazakhstan	988 [r]	1,023 [r]	906 [r]	798 [r]	881 [5]
Korea, Republic of[e]	3,700	3,900	4,000	3,800 [r]	3,900
Malaysia[e]	800	1,300	900	800	900
Mexico[e, 4]	6,500	6,200	6,000	5,500	5,800
Peru[e]	216 [5]	215	215	216 [5]	216
Poland	1,936	2,143	1,952	1,716 [r]	1,800
Romania[e]	1,942 [5]	2,000	2,000	1,600 [r]	2,000
Russia[e]	8,200	8,200	8,200	7,000	8,000
Saudi Arabia[e]	360	400	400	400	400
Serbia	377	320	292 [r]	251 [r]	280
Slovakia	1,104	1,123	1,082	867 [r]	900
Slovenia[e]	1,500	1,500	1,500	1,500 [r]	1,500
South Africa, burnt lime sales	1,585	1,599	1,593	1,375	1,286 [5]
Spain[e, 4]	2,000	2,000	2,000	2,000	2,200
Sweden[e]	750	780	750	600	700
Taiwan[e]	450	470	450	450	450
Thailand[e]	800	800	800	750	750
Tunisia	401	395	369	366 [r]	370 [5]
Turkey[e, 4]	3,800	4,000	4,000	3,800	4,300
United Kingdom[e]	2,000	2,000	1,500	1,500	1,500
United States, including Puerto Rico	21,000	20,200	19,900	15,800	18,300 [5]
Venezuela[e]	400	400	400	400	400
Vietnam	1,592	1,438	1,619 [r]	1,538 [r]	1,600
Zambia[e]	160 [r]	165 [r]	135 [r]	130 [r]	140
Other[e]	1,610 [r]	1,590 [r]	1,660 [r]	1,600 [r]	1,610
Total	285,000 [r]	296,000	307,000	297,000 [r]	311,000

[e]Estimated. [r]Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through April 29, 2011.

[3] In addition to the countries listed, Argentina, Chad, Iraq, Nigeria, Pakistan, Syria, and several other nations produce lime, but output data are not reported; available general information is inadequate to formulate reliable estimates of output levels.

data are not reported; available general information is inadequate to formulate reliable estimates of output levels.

[4] Production estimate based on sales only; data may be incomplete.

[5] Reported figure.

[6] Includes hydraulic lime.

LITHIUM

By Brian W. Jaskula

Domestic survey data and tables were prepared by Susan M. Weaver, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, lithium consumption in the United States was estimated to be 1,100 metric tons (t) of contained lithium, 15% less than the consumption in 2009 and 52% less than in 2008. Although reports indicated that lithium end-use markets for batteries, ceramics and glass, grease, and other industrial applications increased in 2010 from those of 2009, downstream lithium compound producers in the United States may have continued to operate from inventories of lithium compounds in 2010 instead of importing new material. Imports of lithium compounds into the United States in 2010 were similar to those of 2009 but were considerably lower than the average since 1998. Exports of lithium compounds increased to levels seen before the economic downturn that started in late 2008. Actual lithium consumption in the United States may have been greater than the 1,100 t estimated, but no data were available to support a higher estimate. Lithium carbonate consumed in industrial applications and used as a raw material for other lithium compounds in the United States was produced at a domestic brine operation in Nevada and imported from Argentina and Chile.

Lithium has historically been mined from two distinct sources—continental brines and hard rock ore. Chile was the world's leading producer of lithium carbonate, with production from two lithium brine operations on the Salar de Atacama in the Andes Mountains. Concentrated brines were processed at two lithium carbonate plants in Antofagasta. In the United States, production continued at a lithium brine operation with an associated lithium carbonate plant in Silver Peak, NV. Lithium carbonate and lithium chloride also were produced from brines from the Salar del Hombre Muerto in the Andes Mountains in Argentina. In China, lithium carbonate was produced from brines from the Zabayu Salt Lake in western Tibet and from the Dongtai and Xitai Salt Lakes in Qinghai Province. China was the only country that produced large quantities of lithium carbonate from concentrates, mostly from imported Australian spodumene. A large percentage of the lithium carbonate produced in South America was exported to the United States for consumption in industrial applications and as feed material for the production of downstream lithium compounds, such as lithium hydroxide monohydrate, lithium metal, and organic lithium compounds. Australia was, by far, the leading producer of lithium mineral concentrates, and Brazil, China, Portugal, and Zimbabwe also produced significant quantities.

Worldwide lithium resource exploration (led predominantly by Australian and Canadian startup companies) increased significantly in recent years. The continental brine and clay resources of Nevada and geothermal brines of California were a major focus of exploration in the United States, as were the pegmatite and oil brine resources of Canada, and the pegmatite resources of Australia. Additionally, Argentina, Bolivia, and Chile saw significant exploration of their continental brines.

Legislation and Government Programs

Under the authority of the American Recovery and Reinvestment Act of 2009 (ARRA Public Law III–5), the U.S. Department of Energy (DOE) awarded $1.5 billion in grants to accelerate the development of U.S. manufacturing and production capacity of batteries for electric-drive vehicles and battery recycling—lithium-ion battery technology figured prominently in the awards (U.S. Department of Energy, 2009b). In 2010, construction began at 20 ARRA-funded battery and component manufacturing facilities, and 8 demonstration projects were initiated which were expected to produce 13,000 hybrid and electric-drive vehicles and 20,000 charging stations nationwide by 2013. The ARRA was expected to be a significant factor in bringing 30 battery and component factories online by 2012, giving the United States the capacity to produce 20% of the world's advanced vehicle batteries. By 2015, U.S. share of worldwide capacity was anticipated to increase to 40% (U.S. Department of Energy, 2010).

As part of its Advanced Technology Vehicles Manufacturing Incentive Program (ATVM), the DOE in 2009 loaned Nissan North America, Inc. $1.6 billion to convert its Smyrna, TN, plant to produce an electric vehicle (EV), the LEAF, and lithium-ion battery packs. Nissan expected to have production capacity of 150,000 vehicles per year in the United States when the LEAF manufacturing facility, which was scheduled to open in 2012, reaches full capacity in 2015. Tesla Motors, Inc. received a $465 million loan from the DOE to build an automobile manufacturing facility in southern California and a facility to assemble lithium-ion battery packs, electric motors, and electric components in Palo Alto, CA. Tesla's EV, the Model S, was scheduled to be produced in 2012. Fisker Automotive, Inc. received $528 million for the development and production of two models of lithium-ion battery powered plug-in hybrid electric vehicles (PHEVs)—the Karma and the Nina. The Karma and Nina were scheduled to be produced beginning in 2011 and 2012, respectively (U.S. Department of Energy, 2009a; U.S. Government Accountability Office, 2011, p. 14–17).

Recycling

As part of the ARRA in 2009, the DOE awarded $9.5 million to California-based battery recycler Toxco, Inc. to construct the first U.S. recycling facility for lithium-ion vehicle batteries. The company has recycled lithium metal and lithium-ion batteries since 1992 at its facility in British Columbia, Canada. Toxco planned to expand its existing facility in Lancaster, OH, which already recycled nickel-metal hydride and lead-acid batteries from hybrid-electric vehicles (HEVs) (Hamilton, 2009). In early 2011, the company planned to begin construction of a 60,000 square-foot expansion to process up to 9 million pounds of lithium-ion battery packs per year (Gearino, 2011).

Production

The U.S. Geological Survey (USGS) collects domestic production data for lithium from a voluntary canvass of the only U.S. lithium carbonate producer. Chemetall Foote Corp. (a subsidiary of the German company Chemetall, which is owned by Rockwood Holdings, Inc., of Princeton, NJ) responded to the survey, representing 100% of total production. Production and stock data were withheld from publication to avoid disclosing company proprietary data (table 1). It is known, however, that production increased in 2010 from that of 2009 owing to increased activity in lithium end-use industries.

Chemetall Foote produced lithium carbonate from brines near Silver Peak, NV. The company's other U.S. lithium operations included a lithium hydroxide plant in Silver Peak; a butyllithium plant in New Johnsonville, TN; and facilities for producing downstream lithium compounds in Kings Mountain, NC. Chemetall Foote's subsidiary in Chile, Sociedad Chilena de Litio Ltda., produced lithium carbonate, lithium chloride, and lithium hydroxide from a brine deposit.

FMC Corp.'s Lithium Division produced a full range of downstream compounds, lithium metal, and organic lithium compounds at its facility in Bessemer City, NC. The company met its lithium carbonate and lithium chloride requirements with material produced at its operation in Argentina.

In 2010, Chemetall Foote began expanding the lithium production operations at its Silver Peak and Kings Mountain locations. The Silver Peak expansion included commencement of a well drilling program to double the capacity of Chemetall's lithium carbonate production and a geothermal powerplant installation which was expected to help make the Silver Peak operation self-sufficient for electric power. The well drilling program consists of reworking Chemetall's existing brine production wells, installing new production wells, dredging and expanding the current evaporation pond system, and refurbishing the company's lithium carbonate plant. At Kings Mountain, construction of a battery-grade lithium hydroxide production facility was underway. The lithium hydroxide facility expands an existing Chemetall site that produces lithium salts and lithium metal for primary batteries. Both projects were funded in part by a 2009 DOE award of $28.4 million to expand and upgrade the production of lithium compounds for advanced transportation batteries (Rockwood Holdings, Inc., 2010a, b).

In January, American Lithium Minerals, Inc. acquired the North Borate Hills and South Borate Hills lithium projects in southwestern Nevada. The projects were previously reported by U.S. Borax, Inc. to contain abundant lithium mineralization in a strata-bound formation combined with a claystone unit and volcanic tuff. The company entered into a joint-exploration agreement with Japan Oil, Gas and Metals National Corp. (JOGMEC) in June to advance the Borate Hills projects through the economic prefeasibility stage. JOGMEC was to invest $4 million and would earn a 40% interest in the project (American Lithium Minerals Inc., 2010; Japan Oil, Gas and Metals National Corp., 2010).

In July, Japanese trading company Itochu Corp. acquired a 20% stake in California-based Simbol Materials lithium project and exclusive rights to market Simbol's future products in Asia. Simbol's unique geothermal brine reverse osmosis process, if successful, would eliminate the need for solar evaporation, a lengthy process in more common lithium brine operations. The company's lithium carbonate equivalent (LCE) capacity was initially planned for 16,000 metric tons per year (t/yr) (Industrial Minerals, 2010b).

In October, Rodinia Lithium, Inc. (Vancouver, British Columbia, Canada) staked claims in Clayton Valley, NV, bringing its total claim area to approximately 28,000 hectares in an area with the potential of containing a significant lithium brine resource. The mining claims were adjacent to Chemetall Foote's lithium brine operation (Rodinia Lithium, Inc., 2010b).

In May, Western Lithium Canada Corp. (Vancouver) announced the completion of an independent technical and economic assessment on the second of its five lithium-rich hectorite clay deposits at its Kings Valley, NV, project. The second deposit was approximately seven times larger than the first deposit, and the economic assessment showed an indicated resource of 1,365,000 t LCE and an inferred resource of 650,000 t LCE, both at a cutoff grade of 0.20% lithium. In December, two independent laboratories confirmed the extraction of high-purity 99.5% to 99.9% lithium carbonate from pilot test samples provided by Western Lithium (Western Lithium USA Corp., 2010a, b).

Consumption

Lithium is sold as brines, compounds, metal, or mineral concentrates depending on the end use. Lithium's electrochemical reactivity and other unique properties have resulted in many commercial lithium products. For many years, most lithium compounds and minerals were used in the production of ceramics, glass, and primary aluminum. Growth in lithium battery use and decreased use of lithium in aluminum production has resulted in batteries gaining market share. For 2010, Chilean lithium producer Sociedad Química y Minera de Chile S.A. (SQM) listed the main global markets for lithium products as follows—ceramics and glass, 29%; batteries, 27%; lubricating greases, 12%; continuous casting, 5%; air treatment, 4%; polymers, 3%; primary aluminum production, 2%; pharmaceuticals, 2%; and other uses, 16% (Sociedad Química y Minera de Chile S.A., 2011a, p. 39). Roskill Information Services Ltd. offered different consumption estimates for 2010 but confirmed that ceramics and glass remained the top global market for lithium. Roskill's estimates were ceramics and glass, 30%; batteries, 22%; lubricating greases, 12%; air treatment, 5%; metallurgical, 4%; polymers, 4%; primary aluminum production, 2%; pharmaceuticals, 2%; and other uses, 19% (Orocobre Ltd., 2011). The "other uses" category represented several smaller end uses that may have included alloys, construction, dyestuffs, industrial bleaching and sanitation, pool chemicals, and specialty inorganics (FMC Corp., 2008). Domestic end uses for lithium materials may not directly correspond to worldwide consumption, but the data necessary for making more reliable estimates were not available.

If lithium concentrates were included in lithium consumption estimates, the leading use of lithium in the United States likely was in ceramics and glass manufacturing processes. No lithium concentrates, however, were produced in the United States for direct application in ceramics and glass manufacture, and import statistics do not specifically identify lithium ore imports, making it difficult to accurately estimate end uses.

China, Japan, and the Republic of Korea have historically dominated the small to mid-sized lithium-ion battery manufacturing market, accounting for approximately 98% of the market in 2010. Notably in 2010, the Japanese market research firm, the Institute of Information Technology (IIT), reported that the Republic of Korea had overtaken Japan (the primary lithium-ion battery producer since 1991) as the leading manufacturer of lithium-ion batteries. IIT estimated that by 2011, 38.5% of lithium-ion battery production would be concentrated in the Republic of Korea and 38.4% in Japan. Lithium's natural properties make it one of the most attractive battery materials of all the elements. In 2010, lithium-ion batteries accounted for 76% of the portable rechargeable battery market worldwide (Brown, 2011). Worldwide, rechargeable lithium batteries powered most cellular telephones and laptop computers, as well as many heavy-duty power tools. Automakers were working on lithium batteries for HEVs, PHEVs, and EVs.

Addition of lithium carbonate to aluminum potlines lowers the melting point of the cryolite bath, allows a lower operating temperature for the cells, increases the electrical conductivity, and decreases bath viscosity. U.S. primary aluminum production and U.S. lithium consumption for aluminum production saw no change in 2010 from that of 2009. Aluminum production stabilized after cutbacks were made during 2008 and 2009 in response to a significant drop in the price of aluminum in the second half of 2008 (Bray, 2011).

Additional information concerning other lithium end uses can be found in the lithium chapter of the 2006 U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

Prices

Customs values for lithium carbonate imports to the United States were used as an indication of the trends in lithium pricing, although they never exactly reflected the producers' prices for lithium carbonate. In 2010, the average customs unit value for imported lithium carbonate was $4.35 per kilogram, 4% lower than that of 2009. The average customs unit value for imported lithium hydroxide was $4.95 per kilogram, 17% lower than that of 2009. The average unit value of exported lithium carbonate was 16% lower than in 2009 but 33% higher than the average unit value of imported carbonate. The average unit value of exported lithium hydroxide was 13% lower than in 2009 but 26% higher than the average unit value of imported hydroxide. This suggests that the material exported from the United States was higher quality lithium carbonate and lithium hydroxide than that which was imported.

As a result of the 2009 downturn in the lithium market, SQM reduced its lithium carbonate and lithium hydroxide prices by 20% in January 2010. Industry experts reported that by yearend, SQM was selling lithium carbonate for approximately $4.70 per kilogram. Chemetall and FMC most likely reduced prices in 2010 as well, but price data were not available (Sylvester, 2011).

In January, Australian spodumene producer Talison Lithium Ltd. increased glass-grade spodumene (5% lithium oxide) prices by 10% to $380 to $430 per metric ton. At yearend, free-on-board West Virginia glass-grade spodumene (5% lithium oxide) was reported to be selling for $390 to $435 per metric ton (Moores, 2009; Industrial Minerals, 2010a).

Foreign Trade

In 2010, total exports of lithium compounds from the United States increased by 53% compared with those of 2009. About 32% of all U.S. exports of lithium compounds went to Japan, while 16% went to Germany, and 11% went to Belgium. The remainder was divided among many other countries (table 2).

Imports of lithium compounds into the United States increased by 4% in 2010 compared with those of 2009. Of the 10,600 t of lithium compounds imported, 70% came from Argentina, 28% from Chile, and the remainder from several other countries (table 3). This was the second consecutive year that most lithium imports originated from Argentina, rather than Chile. Lithium concentrates from Australia and Zimbabwe may have entered the United States, but because these materials have no unique import code, no import data were available.

World Review

Worldwide production and consumption of lithium increased considerably in 2010. The major lithium producers reported a 30% to 50% increase in sales volumes from that of 2009, and lithium end-use markets for batteries, ceramics and glass, grease, and other industrial applications all increased. World lithium production (excluding U.S. production) was estimated to be 28,100 t of lithium contained in minerals and compounds in 2010, an increase of 44% from that of 2009, and 6% more than that of 2008. Gross weight production figures for lithium carbonate, lithium chloride, lithium hydroxide, and lithium mineral concentrates are listed in table 4. Argentina, Chile, China, and the United States were the leading producers of brine-based lithium carbonate. Significant quantities of lithium compounds and concentrates also were produced in Australia, Brazil, Portugal, and Zimbabwe. Canada, Congo (Kinshasa), Namibia, Russia, Rwanda, and South Africa have produced concentrates in the past. Several brine operations were under development in Argentina; spodumene mining operations were under development in Australia, Canada, and Finland; and a jadarite mining operation was under development in Serbia. Pegmatites containing lithium minerals have been identified in Afghanistan, Austria, France, India, Ireland, Mozambique, Spain, Sweden, and Zaire, but economic conditions have not favored development of the deposits. Lithium has been identified in subsurface brines in Afghanistan, Bolivia, and Israel. Companies in France, Germany, Japan, the Republic of Korea, Russia, Taiwan, and the United Kingdom produced downstream lithium compounds from imported lithium carbonate.

World lithium consumption was estimated by SQM to be 23,500 t of lithium contained in minerals and compounds in 2010, an increase of approximately 42% from SQM's consumption estimate of 2009 (Sociedad Química y Minera de Chile S.A., 2011a, p. 40). A different accounting of total world lithium consumption was reported by Chemetall and Roskill Information Services, both of which indicated consumption to be 22,600 t of lithium contained in minerals and compounds in 2010, an increase of approximately 22% from Roskill's consumption estimate of 2009 (Aul, 2011, p. 6; Robert Baylis, Division Manager, Roskill Information Services, Ltd., oral commun., January 20, 2011). The difference in consumption figures most likely reflected differing estimations of consumer drawdown of lithium inventory.

Total lithium consumption growth averaged 5.5% per year between 2000 and 2010, while lithium consumption in batteries increased on average 20% per year during the same timeframe. Using the Chemetall/Roskill figure for total lithium consumption and Roskill's recent research that estimated the lithium chemical market to be about 75% of total lithium consumption, an estimated 17,000 t of lithium was consumed in chemicals and the remainder as mineral concentrates in the ceramics and glass industry in 2010 (Baylis, 2010b, p. 5).

As of 2008 (the latest year with available data), China and Europe were estimated to be the largest consumers of lithium in the world, at 29% and 28% of total consumption, respectively. Other consumers included Japan, 18%; North America, 13%; the Republic of Korea, 5%; India, 3%; South America, 2%; Russia, 1%; and other, 1% (Roskill Information Services Ltd., 2009, p. 155).

Argentina.—FMC has operated its facility at the Salar de Hombre Muerto since 1998. Initially designed to produce about 12,000 t/yr of lithium carbonate and about 5,500 t/yr of lithium chloride, FMC's lithium chloride production has been as high as 8,800 t. FMC's lithium carbonate production capacity was 17,000 t/yr in 2010, and capacity expansion plans were announced to increase lithium carbonate production capacity to 23,000 t/yr by the end of 2011 (Moores, 2010a). Production of lithium carbonate in 2010 was estimated to be 10,000 t, an increase of 18% from that of 2009. Production of lithium chloride was estimated to be 6,500 t, an increase of 49% from that of 2009. Market research firm Global Business Reports estimated FMC's total 2010 LCE output to be slightly higher, at 17,500 t (Tejerina and Falcó, 2010, p. 68).

In December, The Sentient Group's Rincon Lithium Ltd. commissioned its lithium operation at the Salar del Rincón in the Salta Province and produced its first lithium carbonate. The company expected to have commercial quantities in the market by 2011. The operation was designed to produce 10,000 t/yr of lithium carbonate, 4,000 t/yr of lithium hydroxide, and 3,000 t/yr of lithium chloride (Industrial Minerals, 2010c).

During 2010, Australian exploration company Orocobre Ltd. conducted a definitive feasibility study on its Olaroz lithium project at the Salar de Olaroz in northwestern Argentina; results were expected in early 2011. A previous scoping study indicated the potential to develop an operation with production of 15,000 t/yr of lithium carbonate. In January, Orocobre established a joint venture with Japanese trading house Toyota Tsusho Corp. Toyota Tsusho, a key supplier to Toyota Motor Corp. and several large Asian technology companies including Panasonic Corp. and Sanyo Electric Co., Ltd., anticipated using the joint venture as a means to secure low-cost lithium for its automotive and battery industry partners (Industrial Minerals, 2010f; Orocobre Ltd., 2011, p. 9).

In December, Canadian exploration company Lithium Americas Corp. completed an independent technical and economic assessment of its Cauchari-Olaroz Salars project on the Puna plateau in northwestern Argentina. The economic assessment reported a measured resource of 2,884,000 t LCE and an indicated resource of 2,420,000 t LCE. Lithium Americas expected to complete a preliminary economic assessment in early 2011. Earlier in 2010, the company entered into strategic investment agreements with Canadian car parts manufacturer Magna International Inc. and Japan's Mitsubishi Corp. The companies purchased 13.3% and 4.1%, respectively, of Lithium Americas' common shares in an effort to secure low-cost lithium supplies for their respective company's hybrid and electric-drive vehicle batteries (Hoffman and Keenan, 2010; Lithium Americas Corp., 2011, p. 3–4).

In June, Canadian-based resource company Lithium One Inc. established a joint venture with the Republic of Korea's government-owned mining company Korea Resources Corp. (KORES) to develop Lithium One's Sal de Vida lithium brine project at the Salar del Hombre Muerto. KORES was to receive a 30% interest in the project by funding and delivering a definitive feasibility study, which was expected by yearend 2011 (Lithium One Inc., 2011, p. 3).

In January, Rodinia Lithium acquired three lithium deposits in Salta, Argentina—Salar de Diabillos, Salar de Centenario, and Salar de Ratones. An initial mineral resource estimate of the Salar was expected in early 2011 (Rodinia Lithium Inc., 2010a; 2011).

Australia.—Talison Lithium produced about 25% of global lithium supply from its deposit in Western Australia, which reportedly is the largest spodumene deposit in the world (Department of Mines and Petroleum, 2010, p. 50). The company reported spodumene production of approximately 295,000 t in 2010, an increase of 50% from that of 2009 (Department of Mines and Petroleum, 2011, p. 21). Talison produced two types of lithium concentrate—chemical grade, which is primarily used for conversion into lithium chemicals for applications including lithium batteries, and technical grade, a low iron concentrate which is used directly in the manufacture of ceramics, glass, and heat-proof cookware.

In the wake of China's electric vehicle developments and the resulting expansion of Chinese lithium chemical production, Talison reported in 2010 that 75% of its spodumene concentrate was sold primarily to chemical companies in China, with the remaining 25% sold worldwide to ceramics and glass manufacturers. This was in stark contrast to 2009, when spodumene concentrate sales were divided evenly between ceramic and glass production and chemical conversion (Industrial Minerals, 2010e). The Stage 1 expansion of Talison's chemical grade lithium concentrate production capacity was completed in December, increasing its total lithium concentrate production capacity to 320,000 t/yr. Stage 2 was expected to be completed in 2012, bringing total production capacity to 740,000 t/yr (Talison Lithium, Ltd., 2011).

In October, Galaxy Resources Ltd. commenced lithium concentrate production at its Mount Cattlin spodumene operation, near Ravensthorpe in Western Australia. The Mount Cattlin plant has a lithium concentrate production capacity of 137,000 t/yr. Production from this operation was to supply a lithium carbonate plant in Jiangsu Province, China. (Platts Metals Week, 2010).

In April, Reed Resources Ltd. and its Australian joint-venture partner Mineral Resources Ltd. completed a resource estimate of its Mount Marion lithium project in Western Australia. The study showed the deposit to contain a resource of 8.9 million metric tons (Mt) grading 1.4% lithium oxide, for a total of 128,000 t of contained lithium oxide. Reed anticipated producing battery-grade lithium carbonate beginning in 2011, with a 17,000-t/yr production capacity (Reed Resources Ltd., 2011, p. 12–14).

Bolivia.—Bolivia's undeveloped Salar de Uyuni is the largest salt flat in the world, with an area of more than 11,000 square kilometers and vast lithium resources. In August, Bolivia and the Republic of Korea agreed to a partnership to develop Bolivia's lithium deposits and other resources. In December, Bolivia also agreed to a partnership with Japan to develop Bolivia's lithium resources, as well as a geothermal powerplant project (Kosich, 2010). In 2009, New World Resource Corp. announced that it had acquired the Pastos Grandes brine property in southwestern Bolivia and initiated a brine sampling program. In 2010, the company was drill testing and sampling the third site in an approximate eight-site drill program, with results expected in early 2011 (New World Resource Corp., 2010).

Canada.—In March, Canada Lithium Corp. completed an independent mineral resource assessment on its Quebec Lithium Project. The assessment reported a measured resource of 6.89 Mt grading 1.10% lithium oxide, and an indicated resource of 24.74 Mt grading 1.11% lithium oxide. A 15,000-t/yr LCE production goal was set for 2013. An updated independent mineral resource assessment of the Quebec Lithium Project was published in October, the results of which were under review in 2011. In 2009, Canada Lithium signed a marketing agreement with Mitsui and Co. Ltd. of Japan for exclusive rights to market the company's lithium in China, Japan, and the Republic of Korea (Canada Lithium Corp., 2010a, p. 10; b; 2011).

Channel Resources Ltd. initiated a brine sampling program on its Fox Creek lithium/potash brine project in Alberta from Polaris Capital Ltd. An earlier study of the area by the Government of Alberta indicated potentially economic concentrations of lithium in the aquifer, comparable with those of the brine found in Clayton Valley, NV. As of November, Channel was working to optimize processes to extract lithium and other elements from brine already being produced as a byproduct from a large group of natural gas wells on the Fox Creek permit (Channel Resources Ltd., 2010a; b, p. 2–4).

In November, Lithium One completed an independent mineral resource assessment on its James Bay lithium project in Quebec. The assessment showed an indicated resource of 11.75 Mt grading 1.3% lithium oxide, and an inferred resource of 10.47 Mt grading 1.2% lithium oxide. In December, Lithium One formed a joint venture with Galaxy Resources under which Galaxy Resources would initially acquire 20% of the James Bay project for $3 million. Galaxy Resources could then earn up to 70% through the completion of a definitive feasibility study (Lithium One, Inc., 2010a, b).

Chile.—With a reported 26% of the world lithium market, SQM revenues from its lithium products increased as a result of robust market activity. Sales volume, at 32,400 t, was 52% higher than in 2009, and the value of sales increased by 28% to $150.8 million. SQM's lithium carbonate production capacity was 43,500 t/yr, and its lithium hydroxide production capacity was 6,000 t/yr in 2010 (Sociedad Química y Minera de Chile S.A., 2011a, p. 40, 59; b, p. 12).

Total lithium carbonate production capacity for Chemetall Foote's operations in Chile and the United States increased to 33,000 t/yr in 2010. Chemetall produced an estimated 23,000 to 25,000 t of lithium carbonate in 2010, mostly from its operation in Chile. The company planned to increase production capacity to 40,000 t/yr by 2015 and 50,000 t/yr by 2020. Further increases to 65,000 t/yr would depend on market conditions. In addition, Chemetall planned to increase lithium hydroxide production capacity, currently estimated to be 5,000 t/yr, to 10,000 t/yr by 2015 and 15,000 t/yr by 2020, depending on market conditions. The company used lithium carbonate from Chile as feedstock for some of its downstream chemical production in Germany, Taiwan, and the United States (Aul, 2011, p. 11; Desormeaux, 2011).

In July, Talison Lithium acquired Salares Lithium Inc., giving Talison control of the prospective Salares 7 Project (composed of seven brine lakes) in Chile's Atacama Desert. Talison planned to develop the project to produce battery-grade lithium carbonate (Industrial Minerals, 2010e).

China.—China was the only country that continued to produce large quantities of lithium carbonate from both domestic and imported spodumene. Domestic lithium mineral concentrates were thought to be low grade and were most likely used in glass and ceramic applications. Higher grade spodumene concentrates imported from Australia were generally used in the production of battery-grade lithium carbonate. Lithium minerals were estimated to contain 35% of China's lithium reserves, while lithium brines were estimated to contain the remaining 65% of the reserves (Baylis, 2009, p. 6–7, 11, 13; Roskill Information Services Ltd., 2009, p. 89–91).

In 2010, it was estimated that China's domestic brine-based lithium operations produced between 8,000 t and 10,000 t LCE of technical grade lithium carbonate and lithium hydroxide. China imported approximately 12,000 t LCE of brine-based lithium carbonate, lithium chloride, and concentrated brine from Argentina and Chile. China's total imports from hard rock lithium sources reached approximately 18,000 t LCE (Industrial Minerals, 2011).

The Tibet Lithium New Technology Development Co. had operated a 5,000-t/yr lithium carbonate plant at the Zabayu Salt Lake in western Tibet since 2005, with production capacity expected to increase to 20,000 t/yr. CITIC Guoan Lithium Science & Technology Co., Ltd.'s 35,000-t/yr lithium carbonate plant was brought online in 2007 at the Taijinaier Salt Lake in Qinghai Province and was the largest lithium carbonate plant in

China. In 2010, CITIC opened a 5,000 t/yr battery-grade lithium carbonate plant in Xitai, Qinghai Province. Qinghai Salt Lake Industry Group Co., Ltd. operated a 3,000-t/yr lithium carbonate plant at the Dongtai Salt Lake in Qinghai Province. Production capacity was expected to increase to 20,000 t/yr. Qinghai Salt Lake Lanke Lithium Industry Co., Ltd. completed construction of a 10,000-t/yr lithium carbonate/lithium chloride project in the Chaerhan Salt Lake zone in Qinghai Province. Production was scheduled to commence in 2012 (Tahil, 2007, p. 10, 13; Baylis, 2009, p. 11; Baylis, 2010a, b, p. 19).

Galaxy Resources commenced construction of its Jiangsu Lithium Carbonate Project in Jiangsu Province. Spodumene mined from Galaxy Resources' Mount Cattlin operation in Australia will be shipped to the Jiangsu plant for conversion to battery-grade lithium carbonate. Once complete, the Jiangsu plant was to produce 17,000 t/yr LCE and would supply users across the Asia-Pacific region (Galaxy Resources Ltd., 2010). Galaxy Resources and Mitsubishi signed an agreement in February giving Mitsubishi a significant portion of Galaxy's lithium carbonate production. Galaxy Resources also signed offtake agreements with 13 Chinese lithium battery producers in April for the remainder of its lithium carbonate production (Industrial Minerals, 2010d).

Finland.—In 2008, Norwegian mining company Nordic Mining ASA purchased a controlling stake in Finnish spodumene mining company Keliber Oy. The company then acquired a lithium deposit in the Lantta area of western Finland and planned to establish a 4,000-t/yr lithium carbonate plant. In 2010, Nordic continued with geologic exploration to expand its resource base. When production begins, Nordic was expected to be the first European producer of lithium carbonate from domestic ore (Industrial Minerals, 2008; Nordic Mining ASA, 2010, p. 5).

Japan.—Japan was a leading consumer of lithium compounds and lithium metal. Because Japan has no domestic lithium producers, the country relied heavily on imports. In an effort to mitigate lithium supply risk, Japan's Itochu, JOGMEC, Mitsubishi, Mitsui, and Toyota Tsusho actively partnered with emerging lithium producers worldwide during 2010. In December, the governments of Japan and the Republic of Korea agreed in principal to cooperate jointly in securing lithium supplies (Brown, 2010).

Japanese consumption of lithium compounds was reported by Roskill Information Services to be 18,095 t LCE in 2010, an increase of 36% from that of 2009. Of the 18,095 t total, lithium carbonate accounted for 14,000 t LCE, an increase of 51% from that of 2009. Japanese end-use markets reported strong growth during 2010—production of lithium-ion batteries increased by 33%, ceramics increased by 32%, and continuous casting fluxes increased by 117%. Japanese consumption of lithium metal for use in primary lithium batteries was 180 t in 2010, double that of 2009 (Roskill's Letters from Japan, 2011a, b).

Korea, Republic of.—As part of the effort to secure stable long-term supplies of lithium for its growing automobile, battery, and electronics industries, the Government partnered with key companies in the Republic of Korea, including POSCO and SK Energy Co., Ltd., to acquire lithium from a broad range of sources and countries. In addition to its 2010 joint venture with Lithium One in Argentina and partnership agreement with Bolivia, the Republic of Korea also invested in U.S.-based Pan American Lithium Corp. which owns the rights to 11 salars in Chile and a geothermal project in Mexico. In early 2010, the Government signed an agreement with POSCO and the Korea Institute of Geoscience and Mineral Resources to conduct joint research and build a pilot plant for the commercial production of lithium from sea water. A research facility and offshore plant were scheduled for completion by mid-2011, with lithium extraction to commence in 2012 (Korea.net, 2010; Moores, 2010b; Park, 2011; Watts, 2011).

Serbia.—Jadarite, a mineral species discovered in 2004 by Rio Tinto plc (London, United Kingdom) at Jadar, Serbia, was found to contain a high percentage of lithium oxide. Rio Tinto confirmed that the Jadar deposit could produce battery-grade lithium carbonate and planned to test for additional resources and build a pilot plant beginning in late-2011. The company intended to start lithium carbonate production in 2016 (O'Driscoll, 2011).

Outlook

The percentage of lithium consumption used globally in batteries averaged 20% per year between 2000 and 2010. Demand for lithium-ion batteries (rechargeable) appears to have the greatest potential for growth. Global sales of all rechargeable batteries were expected to total $18.3 billion in 2011, with lithium-ion batteries accounting for 76% of the market. The global market for all rechargeable batteries was forecast to climb to $95 billion by 2020, primarily on anticipated demand for feature-rich, energy intensive cellular "smartphones" and electric vehicles (Brown, 2011). Other lithium end uses were increasing also but at lower rates than batteries. Roskill Information Services Ltd. (2009, p. 156) indicated that annual growth in lithium consumed for pharmaceuticals had averaged 17% from 2000 to 2008, while lithium consumed for continuous casting and greases had averaged 8-year growth rates of 8% and 6%, respectively. Roskill estimated that total world lithium consumption would increase to approximately 27,600 t in 2013, an increase of 22% from Chemetall and Roskill's consumption estimate for 2010 (Baylis, 2010b, p. 13).

Lithium supply security has become a top priority for Asian technology companies. Strategic alliances and joint ventures have been, and are continuing to be, established with lithium exploration companies worldwide to ensure a reliable, diversified supply of lithium for Asia's battery suppliers and vehicle manufacturers. With lithium carbonate being one of the lowest cost components of a lithium-ion battery, the issue to be addressed was not cost difference or production efficiency but supply security attained by acquiring lithium from diversified lithium sources. These measures were taken in 2009 and 2010 by the battery and vehicle companies to alleviate the possibility of future lithium supply disruptions, which could have devastating consequences in a well-established and productive HEV, PHEV, and EV industry.

Research in nanotechnology, the understanding and control of matter at dimensions of approximately 1 to 100 nanometers, has advanced lithium-ion battery technology and further improvements are expected. By altering the nanostructures of the lithium-ion battery's anode and cathode, researchers have been able to increase battery storage capacity, output power, lifespan, and stability, while decreasing the time required to charge the battery (Harrop, 2008). Used in power tools, nanotechnology has enabled lithium-ion batteries to provide power surges of up to 10 times that of conventional lithium-ion batteries (Bullis, 2008). In hybrid vehicles, power surges from lithium-ion batteries enable a vehicle to accelerate faster than with other batteries of the same size (Pontin, 2007). A promising new technology, the lithium-air battery, may be capable of delivering 5 to 10 times more energy density than today's best lithium-ion technology, effectively rivaling the energy density of petroleum. Development of lithium-air battery technology is still in its infancy, however, and commercial production could be 10 to 20 years away (Rahim, 2010).

Increased use of larger lithium-ion batteries can be attributed in part to use in heavy-duty power tools because lithium-ion batteries are replacing nickel-cadmium batteries in power tools. According to a leading manufacturer of power tools, 70% of all cordless power tools in Europe were powered by lithium-ion batteries in 2009. The manufacturer expected lithium-ion power tools to account for 90% of the cordless power tool market by 2011 (Hartung, 2010).

Most global automobile manufacturers have announced plans to use lithium-ion batteries in current and future generations of HEVs, PHEVs, and EVs. Vehicles with lithium-ion batteries from companies such as BYD Co., Ltd., Daimler AG, General Motors Co., Hyundai Group, Mitsubishi Motors, Nissan Motor Co., Ltd., Tesla Motors, Inc., and Volkswagen Group were introduced in 2010. Major automobile manufacturers also formed partnerships with established battery manufacturers to build battery plants for hybrid and electric-drive vehicles and begin mass production of lithium-ion batteries.

The worldwide market for lithium-ion batteries used in transportation was expected to increase to approximately $8 billion by 2015 from $876 million in 2010, largely fueled by government subsidies and incentives. Asian lithium-ion batteries were forecast to comprise 53% of the $8 billion market by 2015 (Pike Research, 2010a).

The successful use of lithium-ion batteries in HEVs, PHEVs, and EVs could greatly increase demand for lithium. As consumption and prices rise, spodumene and other lithium resources that had been considered uneconomic might once again yield economically feasible raw materials for the production of lithium carbonate. New lithium mineral operations under development throughout the world in 2009 and 2010, specifically built to produce battery-grade lithium carbonate, demonstrated a renewed interest in lithium exploration and development.

Various countries worldwide were establishing national alternative energy policies which have the potential to significantly increase lithium demand. Market research firm Pike Research anticipated that Asia, North America, and Western Europe would be at the forefront of adopting utility-scale energy storage systems which would play a large role in the electricity grids of the future, both for long-duration storage as well as short-duration ancillary services. These energy storage systems would be the downstream beneficiaries of the widespread research and innovation on lithium-ion battery development for the transportation sector. Of several energy storage technologies competing within the short-duration ancillary services market, Pike Research indicated that advanced lithium-ion batteries hold the greatest potential. The firm forecast that lithium-ion batteries would capture approximately 70% of the ancillary services market worldwide by 2019, with revenue approaching $4.7 billion (Pike Research, 2010b, c).

In addition to energy storage systems, several other potential growth areas could significantly increase lithium demand by 2020. Lithium used in the form of large-scale solar thermal working fluids in solar thermal power applications and as a working material for passive control mechanisms in nuclear reactor applications could offer substantial opportunities for future lithium growth (Lee and Hykawy, 2011).

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Roskill Information Services Ltd.

TABLE 1

SALIENT LITHIUM STATISTICS[1]

(Metric tons of contained lithium)

	2006	2007	2008	2009	2010
United States:					
Production	W	W	W	W	W
Exports[2]	1,500	1,440	1,450	919	1,410
Imports[2]	3,260	3,140	3,160	1,890	1,960
Consumption[e]	2,500	2,400	2,300	1,300	1,100
Rest of world, production[3]	24,300	25,400	26,500 r	19,500 r	28,100

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1]Data are rounded to no more than three significant digits.

[2]Compounds. Source: U.S. Census Bureau.

[3]Mineral concentrate and lithium carbonate.

TABLE 2

U.S. EXPORTS OF LITHIUM CHEMICALS, BY COMPOUND AND COUNTRY[1]

	2009		2010	
Compound and country	Gross weight (metric tons)	Value[2] (thousands)	Gross weight (metric tons)	Value[2] (thousands)
Lithium carbonate:				
Australia	1 [r]	$6 [r]	1	$14
Canada	157	662	27	117
China	8	28	376	1,650
Germany	576	3,970	677	3,750
India	37	238	56	421
Korea, Republic of	80	514	71	450
Kuwait	42	831	--	--
Mexico	14 [r]	83 [r]	21	74
United Kingdom	53	241	35	128
Other	27 [r]	142 [r]	89	639
Total	995	6,710 [r]	1,350	7,240
Lithium carbonate, U.S.P.:[3]				
Australia	13	75	1	10
India	6	166	9	230
United Kingdom	(4)	9	--	--
Other	11	76	6	435
Total	30	326	16	675
Lithium hydroxide:				
Argentina	65	556	87	750
Australia	64	478	63	464
Belgium	--	--	951	4,660
Canada	90	438	157	912
China	37	345	103	658
Colombia	63	521	46	334
Egypt	73	493	102	679
Germany	397	2,490	676	3,440
India	81	436	340	1,720
Japan	1,870	14,200	2,700	20,000
Korea, Republic of	249	1,750	203	1,250
Mexico	68	322	264	988
Netherlands	99	535	(4)	13
Peru	6	40	16	116
Russia	63	348	210	990
Saudi Arabia	89	742	79	481
Singapore	21	318	52	320
South Africa	77	690	49	505
Taiwan	56	357	291	1,830
Thailand	155	933	274	1,490
United Arab Emirates	--	--	100	572
United Kingdom	673	4,380	152	927
Venezuela	78	704	8	96
Vietnam	24	180	16	110
Other	10	347	21	261
Total	4,400	31,600	6,960	43,600

[r]Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship values.

[3] Pharmaceutical-grade lithium carbonate.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF LITHIUM CHEMICALS BY COMPOUND AND COUNTRY[1]

	2009		2010	
Compound and country	Gross weight (metric tons)	Value[2] (thousands)	Gross weight (metric tons)	Value[2] (thousands)
Lithium carbonate:				
Argentina	6,220	$29,700	7,360	$32,400
Chile	2,900	11,400	2,080	8,640
China	107	454	48	179
Other	26	269	9	37
Total	9,250	41,900	9,500	41,300
Lithium hydroxide:				
Chile	510	3,070	915	4,540
China	306	1,440	99	504
Germany	13	526	--	--
India	28	188	--	--
Japan	15	81	1	41
Norway	21	54	33	57
United Kingdom	37	201	20	109
Other	2	30	2	48
Total	932	5,580	1,070	5,300

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

Source: U.S. Census Bureau.

TABLE 4
LITHIUM MINERALS AND BRINE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Argentina:					
Lithium carbonate	8,228	8,863	9,984	8,450 [r]	10,000
Lithium chloride	8,336	8,828	7,800	4,350 [r]	6,500
Australia, spodumene	222,101	192,277	239,528	197,482 [r]	295,000
Brazil, concentrates	8,585	7,991	8,000 [e]	8,000	8,000
Canada, spodumene[e, 4]	22,500	22,500	22,000	10,000	--
Chile:					
Lithium carbonate from subsurface brine	46,241	51,292	48,469	25,154	48,500
Lithium chloride	1,166	4,185	4,362	2,397	4,400
Lithium hydroxide	3,794	4,160	4,050	2,987	4,050
China, carbonate[e]	15,000	16,000	17,500	20,000	21,000
Portugal, lepidolite	28,497	34,755	34,888 [r]	37,359 [r]	40,600
United States, subsurface brine	W	W	W	W	W
Zimbabwe, amblygonite, eucryptite, lepidolite, petalite, and spodumene[e]	30,000	30,000	25,000	20,000	23,500

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Table includes data available through May 19, 2011.

[2] Estimated data are rounded to no more than three significant digits.

[3] In addition to the countries listed, other nations may produce small quantities of lithium minerals, but output is not reported, and no valid basis is available for estimating production levels.

[4] Based on all Canada's spodumene concentrates (Tantalum Mining Corp. of Canada Ltd.'s Tanco property).

MAGNESIUM

By Deborah A. Kramer

Domestic survey data and tables were prepared by Paula R. Neely, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Primary magnesium was produced by one company in the United States, and much of the U.S. demand was met by imports. Israel was the principal source of imported magnesium metal and alloys. Aluminum alloying, diecasting, and iron and steel desulfurization were, in descending order, the principal end-use applications for magnesium in the United States in 2010. Consumption of primary magnesium in the United States in 2010 was about 9% higher than that in 2009, mostly as a result of the increase in use for iron and steel desulfurization, as U.S. steel production recovered from the economic downturn. China continued to dominate world production of primary magnesium, accounting for 86% of the total (excluding the United States). The United States continued to minimize the quantity of pure and alloy magnesium imported from China through the imposition of antidumping duties.

Legislation and Government Programs

In October, the U.S. Department of Commerce, International Trade Administration (ITA), published the final results of its antidumping duty review of magnesium alloy imports from China. The ITA determined that for April 1, 2008, through March 31, 2009, for Tianjin Magnesium International Co. Ltd. (TMI) the duty was 0% ad valorem, and for other exporters from China, the rate would be 141.49% ad valorem or an individual rate that had been established for a specific company in an earlier review (U.S. Department of Commerce, International Trade Administration, 2010a). In November, the ITA issued a rescission of the antidumping duty order on magnesium alloy from TMI for April 1, 2009, through March 31, 2010, because TMI had not shipped magnesium alloy to the United States during that period (U.S. Department of Commerce, International Trade Administration, 2010b).

In December, the ITA published the final results of its antidumping duty review of pure magnesium imports from China. The ITA determined that for May 1, 2008, through April 30, 2009, for TMI, the duty was 0.73% ad valorem, and for other exporters from China, the rate would be 111.73% ad valorem (U.S. Department of Commerce, International Trade Administration, 2010e).

The ITA also completed an expedited 5-year sunset review of magnesium alloy imports from China and pure and alloy magnesium imports from Russia into the United States. Because no party in the original determination notified the ITA that it intended to participate in the reviews, the ITA determined that revocation of the antidumping orders would likely lead to a continuation of dumping. As a result, the ITA maintained the antidumping duty orders (U.S. Department of Commerce, International Trade Administration, 2010c).

Russian magnesium producer VSMPO-Avisma Corp. requested that the International Trade Commission conduct a 5-year sunset review of antidumping duties for pure magnesium imported from Russia into the United States. In August 2009, the ITA had set an antidumping duty rate of 43.58% ad valorem on magnesium metal from VSMPO-Avisma for April 1, 2007, through March 31, 2008, and a rate of 21.71% ad valorem for metal from Russian company JSC Solikamsk Magnesium Works (SMW). VSMPO-Avisma said that imports from Russia would not increase significantly if the antidumping duty order were revoked (Jennemann, 2010).

In September, the ITA published the final results of its antidumping duty review of magnesium imports from Russia for April 1, 2008, through March 31, 2009. For VSMPO-Avisma, the ITA set a duty of 0% ad valorem. Because SMW did not ship magnesium into the United States in the period of review, its duty was set at the rate that was determined the last time the company had U.S. sales or shipments (U.S. Department of Commerce, International Trade Administration, 2010d).

Federal authorities charged six people and three companies with importing substandard magnesium powder from China into the United States, where it was used to make 1.8 million countermeasure flares that were intended to be used by military aircraft to divert heat-seeking missiles. Officials said that none of the flares made it onto aircraft before being quarantined, and that all would be destroyed. The Chinese magnesium was mixed with aluminum nuggets and mislabeled when it entered the country in sealed drums, so that it would not be subject to a nearly 306% antidumping duty (Thompson, 2010).

Production

U.S. Magnesium was the sole producer of primary magnesium in the United States. The company recovered magnesium electrolytically from brines from the Great Salt Lake at its 52,000-metric-ton-per-year (t/yr) plant in Rowley, UT. U.S. Magnesium renewed plans to increase magnesium production capacity at its Rowley plant to 63,500 t/yr by 2013. The plans to increase capacity were originally proposed in 2004, but because of the global recession, the plans were put on hold in 2009. About 11,000 t/yr of U.S. Magnesium's production was committed to Allegheny Technologies Inc. (ATI) for use in its nearby titanium sponge plant, which started operations in 2009. This magnesium, which is used in the Kroll process to produce titanium sponge from titanium tetrachloride, was committed for several years, until ATI's plant reaches full capacity (McBeth, 2010c).

Environmental Issues

The cover gas sulfur hexafluoride (SF_6) that is used to protect molten magnesium from oxidation has been identified as a potential factor in global warming. Although studies on the effect of the gas continued, its long atmospheric life (about 3,000 years) and high potential as a greenhouse gas (GHG) (23,900 times the global warming potential of carbon dioxide) resulted in a call for voluntary reductions in emissions. In 1999, the U.S. magnesium industry, the International Magnesium Association, and the U.S. Environmental Protection Agency (EPA) began a voluntary partnership to reduce emissions of SF_6. The major processes that require SF_6 melt protection are primary production; secondary production; die, permanent mold, and sand casting; wrought products production; and anode production. According to the EPA, the magnesium industry emitted 1.1 teragram CO_2 equivalent of SF_6 in 2009, representing a decrease of approximately 45% from 2008 emissions. The decrease may be attributed to diecasting facilities closing in the United States and reduced demand from the American automobile industry and other industrial sectors. An issue that was expected to be addressed in future inventories is the likely adoption of alternate cover gases by U.S. magnesium producers and processors. These cover gases, which include AM-cover™ [containing hydroflurocarbon-134a (HFC–134a)] and Novec™ 612 (dodecafluoro-2-methylpentan-3-one), have lower global warming potential than SF_6 and tend to quickly decompose during their exposure to the molten metal. Magnesium producers and processors voluntarily have begun using these cover gases in a limited fashion (U.S. Environmental Protection Agency, 2011, p. 4–52—4–54).

On June 28, the EPA issued a final rule that requires annual GHG emissions reporting from four source categories—magnesium production, underground coal mines, industrial waste landfills, and industrial wastewater treatment. For magnesium, each facility must report total annual emissions for each of the following cover or carrier gases: SF_6, HFC–134a, the fluorinated ketone FK 5–1–12, carbon dioxide, and any other fluorinated GHG as defined in the rule. Collection of the data was scheduled to begin on January 1, 2011, with the first report due on March 31, 2012 (U.S. Environmental Protection Agency, 2010).

In a ruling by the 10th Circuit Court of Appeals, a 2007 decision exempting U.S. Magnesium's waste streams from regulation by the EPA under the Resource Conservation and Recovery Act (RCRA) was reversed. In the lawsuit originally begun in 2001, U.S. Magnesium argued that the EPA exempted five wastes from regulation under subtitle C of RCRA. U.S. Magnesium claimed that the EPA could not change that interpretation, at least not without first complying with the notice and comment procedures of the Administrative Procedure Act. The district court had agreed with U.S. Magnesium, but, according to the new appellate court ruling, because the EPA never previously adopted a definitive interpretation, it remained free to change its mind and issue a new interpretation of its own regulations. The appellate court remanded the decision to the district court (Leagle.com, 2010).

In November, U.S. Magnesium appealed the EPA's decision to declare its magnesium production facility in Rowley as a Superfund site. The company argued that the EPA broke its own rules by designating the plant as a Superfund site. The company also contended that although there are four sources of pollution on the site, they cannot be aggregated to show a higher waste output, and that two birds listed as affected by the plant's operation are not threatened or endangered. Because the EPA ruling that U.S. Magnesium's facility is a Superfund site is considered a Federal regulation, the appeal went directly to the Court of Appeals for the District of Columbia (Burr, 2010).

Consumption

Data for magnesium metal are collected from two voluntary surveys of U.S. operations by the U.S. Geological Survey. Of the 62 companies canvassed for magnesium consumption data, 50% responded, representing 45% of the magnesium-base scrap consumption listed in table 2 and the primary magnesium consumption listed in table 3. Data for the 31 nonrespondents were estimated on the basis of prior-year consumption levels and other factors.

Reported primary magnesium consumption in 2010 was about 9% higher than that in 2009 (table 3), which reflected a slight increase in the U.S. economy. Aluminum alloying was the principal use for primary magnesium, accounting for 43% of the total, followed by diecasting with 35% and iron and steel desulfurization with 11%. Primary magnesium use in aluminum alloying increased slightly although primary aluminum production in the United States in 2010 was about the same as that in 2009. A 36% increase in steel production from 2009 to 2010 was responsible for a 50% increase in the use of magnesium for desulfurization.

Hart Metals Inc. (a subsidiary of United Kingdom-based Magnesium Elektron Ltd.) received $1.6 million in Federal funding to design magnesium components for military vehicles. The funding was expected to be used to finance construction and installation of an atomizer by yearend 2010. Hart Metals would then start developing alloys and adjusting their properties to find the right mix to meet military specifications. Hart Metals already manufactured magnesium flares for the military (Pangonis, 2010). ESM Group Inc. announced that it would construct an atomized magnesium plant at its Saxonburg, PA, operations by the second quarter of 2011. Although the company did not specify the plant's expected production capacity, magnesium powder produced at the plant would be targeted to defense markets (Riley, 2010a).

In October, a fire at Magnesium Elektron's Madison, IL, magnesium sheet plant destroyed one of the plant's reheating furnaces, but because the plant was operating at less than its production capacity, the fire did not disrupt the company's supply to its customers. The plant produced magnesium sheet for aerospace and commercial applications (Riley, 2010b).

Metal-Oxygen Separation Technologies Inc. (Natick, MA) received a $260,000 grant from the U.S. Department of Energy (DOE) to develop an efficient one-step electrolytic process to recycle low-grade and post-consumer magnesium scrap. The company was developing an electrolytic process to recover magnesium from magnesium oxide, unlike traditional electrolytic processes that use magnesium chloride as a feed material. The National Science Foundation provided startup funding of $100,000 to the company in June 2009, and the company received $1.1 million in grants in 2010 from the DOE, including the $260,000 grant noted above (Alspach, 2010).

A new technology to produce magnesium sheet has been developed by nanoMAG, LLC (a subsidiary of Thixomat, Inc.). The process is related to the thixomolding injection molding process, which converts magnesium alloys into complex parts. nanoMAG claimed that the fine-grain sheet material forms easily, allowing fabrication of net-shape finished components currently not available. The new sheet was said to provide 200% higher strength and improved toughness compared to conventional magnesium sheet, while also providing the strength of carbon steel sheet at one-fourth the weight. The company planned to target the new sheet product to applications in military vehicle armor, resorbable biomedical implants, and structural aerospace applications (Smock, 2010).

European steelmaker Corus (a subsidiary of India's Tata Steel Group) reportedly developed improved anticorrosion steel coatings dedicated to the automotive industry. One new coating, which contains a small quantity of magnesium and aluminum and less zinc than usual, was at the commercialization phase and undergoing tests. Its claimed improved corrosion performance could enable Corus to produce steel sheet with a thinner coating layer, which could reduce the weight of individual structural car body components by up to 35% compared to conventional steels without sacrificing safety requirements (Metal-Pages, 2010c).

McPhy Energy, a French company founded in January 2008 to industrialize and commercialize a new technology for the solid storage of hydrogen in the form of magnesium hydride, raised €13.7 million ($16.9 million) in a second round of financing to scale up its hydrogen storage technology. Following a €1.6 million ($1.9 million) first round of financing in January 2009, the company established a production line and created a reservoir of magnesium hydride that was delivered to the French Laboratory of Innovation for New Energy Technologies and Nanomaterials (CEA-Liten) in March 2010 for testing on an industrial scale. In April, McPhy Energy signed a research contract with CEA-Liten to manufacture two full-size magnesium hydride storage prototypes and to test them at industrial scale. During the test campaign, they would be coupled to an electrolyzer and a fuel cell simulating a real-world renewable energy storage application (EETimes, 2010).

Stocks

Producers' yearend 2010 stocks of primary magnesium were about the same as those at yearend 2009; producer stock data were withheld to avoid disclosing company proprietary data. Consumer stocks of primary and alloy magnesium were 4,230 metric tons (t) at yearend 2010, 22% lower than the yearend 2009 level of 5,420 t (revised).

Prices

The U.S. spot Western magnesium price rose in the first quarter of the year, stabilized in the second and third quarters, and fell slightly to end the year at only about 10 cents per pound more than that at the beginning of 2010. In the first quarter, the increase in magnesium consumption that had begun in the third quarter of 2009 led to a drawdown in stocks, which fueled purchases, and, as a result, led to increased prices (McBeth and Yee, 2010). U.S. magnesium demand remained slow through the second quarter, and the summer is generally a time of reduced consumption because of automotive plant closures. General Motors Corp., however, announced that it would keep 9 of its 11 automobile assembly plants operating during the traditional shutdown period from June 28 to July 9 because of increased demand for automobiles. The decision to keep the plants operating through the summer was intended to increase production by 56,000 vehicles (Metal-Pages, 2010b).

Press reports indicated that although U.S. magnesium consumption had diminished from the level before the economic recession, domestic supplies were barely sufficient to meet this consumption level, which led to stable prices in the third quarter of 2010 (Metal-Pages, 2010d). The weakening economy, concern about automotive markets, and a reduction in inventories by consumers were the principal reasons for the price decline in the fourth quarter.

Magnesium contracts in North America for 2011 reportedly settled between $2.30 and $2.35 per pound for pure magnesium or diecasting alloy and $1.80 to $1.90 per pound for secondary 90/10 magnesium alloy (McBeth, 2010b).

Foreign Trade

Total magnesium exports for 2010 were about 25% less than those in 2009 (table 5). Canada (43%), Mexico (22%), and Singapore (15%) were the principal destinations.

Magnesium imports for consumption in 2010 were about 12% higher than those in 2009 (table 6). Magnesium metal (containing at least 99.8% by weight of magnesium) imports were 15% lower compared with those in 2009, but alloy imports were 143% higher. Israel (35%) was the principal source of magnesium imports, mostly metal and alloys, and Canada (21%) was the second ranked source of magnesium imports, mostly waste and scrap.

Taiwan, with a 22% share of magnesium alloy imports into the United States in 2010, has increased its imports significantly because recycler Pinda Technology Co. Ltd. signed an agreement with U.S.-based Greenwich Metals Ltd. to market its product in the United States. Pinda Technology can produce 7,200 t/yr of magnesium from diecasting scrap but had been producing at about 4,000 t/yr because of a shortage of scrap. Pinda Technology's material is marketed to U.S. diecasters as an alternative to domestically produced magnesium (Riley, 2011).

World Review

European Union.—A ad hoc working group under the Raw Materials Supply Group that was formed by the European Union (EU) analyzed 41 materials to determine their economic importance and supply risk, and determined that magnesium was 1 of 14 critical materials. The group recommended a number of steps to improve the availability of reliable, consistent statistical information; improve the knowledge of the availability of resources and their flow into products through the value-added chains of the EU economies; encourage more research into life-cycle assessments for raw materials and their products on a cradle-to-grave basis; and create a working group to analyze the impact of emerging technologies on demand for raw materials (European Commission Enterprise and Industry, 2010, p. 5–10).

Australia.—Latrobe Magnesium Ltd. continued to develop its process to recover magnesium from coal fly ash. Experimental work demonstrated progressive reductions in sulfur and iron in the fly ash, which resulted in increased metallic magnesium recoveries of up to 94%. Based on this, Latrobe Magnesium began a prefeasibility study, which was expected to be completed by the end of March 2011, to develop a 5,000-t/yr magnesium plant. Construction time for the plant was estimated to be 12 months. In December 2010, the company signed an extension of its existing agreement with Hazelwood Power. Under the agreement, Hazelwood Power agreed to supply ash from the Hazelwood Power Station, provide land adjacent to the Hazelwood Power Station on which to construct a primary magnesium plant, and supply electricity at a competitive price (Latrobe Magnesium Ltd., 2011, p. 4–6).

Canada.—Gossan Resources Ltd. (Winnipeg, Manitoba) reported that results from recently completed phase 3 bench-scale tests confirmed that the Zuliani process produced magnesium metal under atmospheric conditions at high raw material efficiencies. Compared to a magnesium metal plant using the Pidgeon process in China, the Zuliani process used 33% less ferrosilicon and 23% less dolomite to produce an equivalent quantity of magnesium. As a result of the successful tests, Gossan planned phase 4 testing of the Zuliani process, which would increase the experimental scale by more than 100 times compared to the phase 3 bench-scale tests. Gossan planned to recover magnesium from a dolomite deposit in south-central Manitoba (Gossan Resources Ltd., 2010).

China.—According to the China Nonferrous Metals Industry Association, China produced 654,000 metric tons (t) of magnesium in 2010, 31% more than 2009 production. Approximately 384,000 t of magnesium was exported in 2010, with about one-half as unwrought magnesium (China Metal Market—Precious & Minor Metals Monthly, 2011).

In May, China Direct Industries, Inc. announced that it was restarting production of primary magnesium at two facilities in China—Baotou Changxin Magnesium Co., Ltd. (Inner Mongolia), with a capacity of 20,000 t/yr and Taiyuan Changxin Magnesium Co. Ltd. (Shanxi Province), with a capacity of 10,000 t/yr. The company scheduled production at the facilities to begin in July or August 2010 after the plants had been idle throughout 2009 because of weak demand. China Direct also operated Shanxi Gu County Golden Magnesium Co. Ltd. (Shanxi Province) with a production capacity of 12,000 t/yr; production at this plant reportedly reached its full capacity in May (China Direct Industries, Inc., 2010).

The municipal government of Anshan in Liaoning Province secured investment, through Magnesium Resources Corp. of China Ltd., to build a magnesium plant in the city's Haicheng district. Magnesium Resources was expected to invest up to $1.5 billion in the construction of the facility, which would have a production capacity of 200,000 t/yr of magnesium metal and 50,000 t/yr of magnesium alloys. The first phase of the project was expected to be completed in mid-2010 (Metal-Pages, 2010a).

Fugu Xintian Magnesium Alloy Co. Ltd. (Shaanxi Province) planned to expand its magnesium ingot production capacity to 20,000 t/yr from 10,000 t/yr. The company planned to invest $8.8 million to set up a new production line with a capacity of 10,000 t/yr of pure magnesium and 10,000 t/yr of magnesium alloy to be completed by yearend 2010. The company also produced 40,000 t/yr of coal tar at its plant, which served as the fuel supply for magnesium ingot production and reduced the plant's production cost (Metal-Pages, 2010e).

As part of its 5-year plan, China's Government would close currently producing magnesium plants with a production capacity of less than 15,000 t/yr and require that all new plants have a production capacity of at least 20,000 t/yr. The new rules were scheduled to be implemented in 2011. In addition, the new regulations require magnesium plants to consume a maximum of 5.5 to 6.0 t of coal per ton of magnesium produced; some plants have consumed as much as 11 to 18 t of coal per ton of magnesium. The goals of the new regulations were to eliminate small plants that produce substandard (less than 99.9%-pure) magnesium and to reduce emissions (Leung and Yee, 2010).

Malaysia.—The first production of magnesium from CVM Minerals Ltd.'s (Kuala Lumpur) plant in Malaysia began in June, although the plant had not ramped up to commercial-scale production by yearend. The facility in Taiping in the state of Perak used locally mined dolomite feedstock for a Pidgeon-process plant using natural gas to fuel the process. The initial production capacity was 15,000 t/yr. CVM planned to double the capacity to 30,000 t/yr in the future and to begin producing magnesium alloys (CVM Minerals Ltd., 2010, p. 8).

Mexico.—Garfield Alloys Inc. (Garfield Heights, OH) announced that it was closing its Garfield Alloys de Mexico S. de R.L. de C.V. subsidiary, which opened in 2005 with a 4,000 t/yr capacity to recycle various types of magnesium scrap. Production at the plant stopped in December, and the closure was expected to be completed in the first quarter of 2011. Garfield Alloys determined that capacity at its existing U.S. operations in Bellevue, OH, (MagReTech), which recycles class I scrap, and outside Cleveland, OH, which processes magnesium dross, would be sufficient to meet customer needs (McBeth, 2010a).

Outlook

U.S. magnesium consumption was expected to continue to be directly correlated to the global economy. If the economy recovers, magnesium consumption in the United States should return to its earlier levels. A significant portion of U.S. demand for magnesium will depend on its use in aluminum alloys. Aluminum production in 2011 was expected to increase from that in 2010, with U.S. aluminum producers bringing some additional capacity onstream that had been shut since 2008 and 2009. As of June 1, 2011, however, the U.S. aluminum industry was operating at only 60% of its total production capacity.

Most of the growth in magnesium use in the past decade resulted from its increased use in automotive applications because of its light weight, and any increase in automobile manufacturing would be expected to result in an increase in the use of magnesium. However, automotive manufacturers may be less likely to choose magnesium than other lightweight materials, such as plastic, because of the limited availability from multiple producers. Because of antidumping duties assessed on magnesium imported from China, the leading producer, automobile manufacturers are limited to sourcing primary magnesium from one company in Brazil, one in Israel, two in Russia, and one in the United States. The limited number of suppliers was one of the reasons that the U.S. automotive industry was reluctant to use magnesium for many years. As a result of the downturn in the U.S. economy and the limited number of suppliers of magnesium, the U.S. diecasting industry has lost at least six large diecasting facilities since 2008. According to Ward's Automotive Group (2011), U.S. light vehicle production for the first half of 2011 was 8.8% higher than that in 2010, which is likely to lead to increased magnesium diecasting production and use in 2011.

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TABLE 1
SALIENT MAGNESIUM STATISTICS[1]

(Metric tons unless otherwise specified)

	2006	2007	2008	2009	2010
United States:					
Production:					
Primary magnesium	W	W	W	W	W
Secondary magnesium	94,900 [r]	89,300 [r]	88,400 [r]	68,600 [r]	72,000
Exports	12,300	14,800	14,400	19,600	14,800
Imports for consumption	75,300	71,800	83,300	47,300	52,700
Consumption, primary	77,600	72,200	64,500	50,900	55,700
Yearend stocks, producer	W	W	W	W	W
Price[2] dollars per pound	1.35–1.45	2.00–2.50	3.05–3.25	2.20–2.40	2.35–2.50
World, primary production[e]	675,000	751,000	670,000	598,000 [r]	757,000

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Source: Platts Metals Week.

TABLE 2
MAGNESIUM RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY[1]

(Metric tons)

	2009	2010
KIND OF SCRAP		
New scrap:		
Magnesium-base	17,200	21,100
Aluminum-base	30,900 [r]	30,500
Total	48,100 [r]	51,500
Old scrap:		
Magnesium-base	1,210	1,210
Aluminum-base	19,300 [r]	19,300
Total	20,500 [r]	20,500
Grand total	68,600 [r]	72,000
FORM OF RECOVERY		
Magnesium alloy ingot[2]	W	W
Magnesium alloy castings	7,970	6,520
Aluminum alloys	51,700 [r]	54,600
Other[3]	8,900	10,900
Total	68,600 [r]	72,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes secondary magnesium content of both secondary and primary alloy ingot.

[3] Includes chemical and other dissipative uses, cathodic protection, and data indicated by symbol W.

TABLE 3
U.S. CONSUMPTION OF PRIMARY MAGNESIUM, BY USE[1]

(Metric tons)

Use	2009	2010
For structural products:		
Castings:		
Die	19,100	19,600
Permanent mold	107 [r]	163
Sand	410	424
Wrought products[2]	1,090 [r]	2,120
Total	20,700	22,300
For distributive or sacrificial purposes:		
Aluminum alloys	23,000	23,800
Cathodic protection (anodes)	686	709
Iron and steel desulfurization	3,970	5,960
Nodular iron	72	412
Reducing agent for titanium, zirconium, hafnium, uranium, beryllium	1,120	882
Other[3]	1,350	1,630
Total	30,200	33,400
Grand total	50,900	55,700

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes sheet and plate and forgings.

[3] Includes chemicals and scavenger, deoxidizer, and powder.

TABLE 4
YEAREND MAGNESIUM PRICES

		2009	2010
U.S. spot dealer import	dollars per pound	2.25–2.40	2.25–2.40
U.S. spot Western	do.	2.20–2.40	2.35–2.50
China	dollars per metric ton	2,630–2,700	2,900–2,950
European free market	do.	2,700–2,800	2,950–3,050

do. Ditto.

Source: Platts Metals Week.

TABLE 5

U.S. EXPORTS OF MAGNESIUM, BY COUNTRY[1]

Country	Waste and scrap		Metal		Alloys		Powder, sheets, tubing, ribbons, wire, other forms	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009:								
Brazil	--	--	220	$648	2,090	$10,100	21	$761
Canada	2,050	$4,630	2,610	8,470	5,290	22,100	217	3,330
Mexico	165	453	520	1,800	1,050	4,760	881	5,480
Singapore	--	--	2,550	9,150	262	944	9	191
United Kingdom	--	--	--	--	10	51	340	10,300
Other	67	119	221	461	488	2,470	581	10,500
Total	2,280	5,200	6,120	20,500	9,190	40,400	2,050	30,500
2010:								
Brazil	--	--	60	220	396	2,350	15	856
Canada	85	219	1,730	8,400	4,270	18,100	272	4,090
Mexico	112	205	937	2,730	1,500	6,380	648	4,130
Singapore	--	--	2,110	7,070	61	386	37	743
United Kingdom	4	11	--	--	29	292	461	15,000
Other	280	367	465	1,340	676	3,400	638	11,800
Total	481	802	5,300	19,800	6,940	30,900	2,070	36,600

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF MAGNESIUM, BY COUNTRY[1]

Country	Waste and scrap		Metal		Alloys, magnesium content		Powder, sheets, tubing, ribbons, wire, other forms, magnesium content	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009:								
Canada	14,800	$24,300	22	$112	687	$3,360	2	$85
China	50	49	4,970	22,600	133	649	122	1,530
Israel	--	--	15,300	58,500	1,040	4,890	--	--
Kazakhstan	--	--	333	918	--	--	--	--
Mexico	805	1,290	25	210	683	2,660	6	323
Russia	--	--	307	1,200	8	75	2	102
United Kingdom	1,410	4,520	5	32	703	10,600	26	1,300
Other^r	3,840	10,200	433	3,160	1,530	7,530	47	838
Total	20,900	40,300	21,400	86,800	4,790	29,800	205	4,170
2010:								
Canada	10,100	25,300	30	117	835	2,840	306	1,530
China	196	292	93	560	1,270	3,370	335	2,740
Israel	--	--	15,800	73,200	2,510	13,200	--	--
Kazakhstan	--	--	875	3,520	--	--	--	--
Mexico	687	1,650	--	--	1,130	4,830	63	1,250
Russia	--	--	618	1,820	--	--	--	--
United Kingdom	3,280	7,370	--	--	807	11,400	40	1,920
Other	7,850	22,000	807	4,310	5,080	18,800	44	1,730
Total	22,100	56,500	18,200	83,500	11,600	54,400	788	9,160

^r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 7
WORLD ANNUAL PRIMARY MAGNESIUM PRODUCTION CAPACITY, DECEMBER 31, 2010[1]

(Metric tons)

Country	Capacity
Brazil	22,000
China	1,080,000
India	900
Israel	32,000
Kazakhstan	30,000
Russia	80,000
Serbia	5,000
Ukraine	15,000
United States	52,000
Total	1,320,000

[1] Includes capacity at operating plants as well as at plants on standby basis.

TABLE 8
MAGNESIUM: ESTIMATED PRIMARY WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Brazil	6,000	18,000	15,000	16,000	16,000
Canada	65,000 [3]	16,300 [3]	2,000 [3]	--	--
China	520,000	625,000	559,000	501,000	654,000
Israel	24,581 [4]	29,618 [4]	32,051 [4]	19,405 [r, 4]	25,000
Kazakhstan	21,000	21,000	21,000	21,000	21,000
Russia[3]	35,000	37,000	37,000	37,000	37,000
Serbia	1,500	2,000	1,500	1,500	1,500
Ukraine	2,200	2,500	2,000	2,000	2,000
United States	W	W	W	W	W
Total	675,000	751,000	670,000	598,000 [r]	757,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 13, 2011.

[3] Includes secondary.

[4] Reported figure.

MAGNESIUM COMPOUNDS

By Deborah A. Kramer

Domestic survey data and tables were prepared by Paula R. Neely, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, a significant increase in domestic steel production led to increased production, imports for consumption, and consumption of dead-burned (refractory) magnesia in the United States. Dead-burned magnesia production nearly doubled, and imports for consumption increased by more than 100% to meet the increased demand for refractories from the steel industry. China continued to be the principal source of imports of dead-burned magnesia, accounting for 66% of the total. U.S. production, imports for consumption, and consumption of caustic-calcined magnesia also increased, but not as significantly as those of dead-burned magnesia.

About 56% of U.S. magnesium compounds production came from seawater and well and lake brines. The remainder was recovered from dolomite, magnesite, and olivine. With increased steel production, refractory applications represented about 53% of total U.S. consumption of magnesium compounds, which was a significant increase from 40% of the 2009 total. The remaining 47% of total consumption was used in agricultural, chemical, environmental, and other applications.

Legislation and Government Programs

In August, the U.S. Department of Commerce, International Trade Administration (ITA) published its final determinations of its investigation of dumping of magnesia-carbon brick from China and Mexico into the United States. The ITA established a dumping margin of 128.10% ad valorem for 14 producing and (or) exporting companies in China and 236% ad valorem as the China-wide rate. For Mexico, the ITA determined a dumping margin of 57.90% ad valorem (U.S. Department of Commerce, International Trade Administration, 2010a, c). Because the ITA also found that subsidies existed for magnesia-carbon bricks exported from China, it established countervailing duties of 24.24% ad valorem for most companies exporting from China, with one firm having a rate of 253.87% ad valorem (U.S. Department of Commerce, International Trade Administration, 2010b). U.S. magnesia-carbon brick manufacturer Resco Products Inc. had filed the original complaint in 2009.

Production

As the global economy began to recover, domestic production of all magnesium compounds increased. U.S. shipments of caustic-calcined magnesia were 10% higher than those in 2009, and refractory magnesia shipments increased significantly in response to increased U.S. steel production (table 3). Magnesium hydroxide shipments increased by 3% from those in 2009.

Data for magnesium compounds were collected by the U.S. Geological Survey (USGS) from one voluntary survey of U.S. operations. Of the 12 operations canvassed, 10 responded, representing 99% of the magnesium compounds shipped and used, including data for some compounds that were not reportable in table 3. Data for the two nonrespondents were estimated on the basis of prior-year production levels.

The largest capacity magnesite processing facilities in the world are in China and Russia. These countries accounted for about two-thirds of the world magnesia from magnesite production capacity. Japan, the Netherlands, and the United States accounted for about 56% of the world's magnesia production capacity from seawater or brines. Fused magnesia was produced in Australia, Brazil, China, Israel, Japan, the Republic of Korea, Mexico, Russia, the United Kingdom, and the United States. World production capacity for fused magnesia was estimated to be about 560,000 metric tons per year (t/yr), including about 372,000 t/yr of capacity in China (Schroeder, 2006). Fused magnesia was produced by one company in the United States, UCM Group PLC of the United Kingdom, which operated a plant in Cherokee, AL, through its UCM Magnesia Inc. subsidiary.

Norway traditionally has been the world's principal producer and supplier of olivine, but since 2004, when a new olivine mine was opened in Greenland, Norway's share of world production has dropped to about 30% from about 66%. Other producers include Australia, Austria, Brazil, China, Greece, Italy, Japan, the Republic of Korea, Mexico, Spain, Taiwan, Turkey, and the United States. Roberts (2008) estimated that total world production of olivine in 2008 was 8.4 million metric tons (Mt), although the total was likely smaller in 2010 because of mine closures that resulted from the global economic downturn in 2008–09. Two companies in the United States produced olivine—Unimin Corp. and Olivine Corp. Unimin operated a mine in North Carolina and processing plants in Indiana and North Carolina. Olivine operated one mine and one processing plant in Washington.

International Brucite Corp. (a subsidiary of Texas Architectural Aggregate, Inc.) (TAA) purchased the Marble Canyon, TX, deposit of brucitic marble from Applied Chemical Magnesias Corp., which had filed for bankruptcy in 2008. TAA had owned the deposit before Applied Chemical Magnesias was formed in 1998 to exploit the deposit. According to TAA, the deposit contained 2.35 Mt of proven reserves. In November, International Brucite contacted Austin Technology Incubator for assistance in starting its new business. Austin Technology Incubator is a nonprofit unit of the University of Texas at Austin that provides support to its member companies to help them transition from early-stage ventures to successful technology businesses. International Brucite planned to market its product for water-treatment and industrial neutralization applications (Industrial Minerals, 2011).

Some magnesia consumers and U.S. farmers filed class action lawsuits against Premier Magnesia LLC, credit agency YAS Inc., and Japanese firm Sumitomo Corp. alleging that these companies engaged in "price fixing" of magnesia-containing products that were manufactured or distributed after January 1, 2004. The complaint stated that the three companies agreed to control the price of magnesia used in feed and fertilizers, and attorneys for the plaintiffs were asking for relief for indirect purchasers of the material. The lawsuit was originally filed in September by Orangeburg Milling Co. Inc. as a class action lawsuit, and other groups joined the lawsuit before yearend (O'Driscoll, 2011).

Consumption

In 2010, the environmental applications sector (water treatment and stack-gas scrubbing) was the largest tonnage end use for caustic-calcined magnesia, with 47% of the total. The following categories (with the individual components in descending order of consumption in parentheses) were the other end-use sectors for caustic-calcined magnesia: agriculture (animal feed and fertilizers), 28%, and chemical intermediates, 23%. The remaining categories each had less than 2% of the total use—manufacturing (rubber and electrical), construction (primarily oxychloride and oxysulfate cements), and medicines and cosmetics.

Magnesium hydroxide was used for water treatment, as a chemical intermediate, in medicines and pharmaceuticals, and in fertilizer (in descending order of quantity). Magnesium sulfate was used mostly for chemicals, fertilizers, pulp and paper, rubber, pharmaceuticals, and water treatment (in descending order of quantity). Magnesium chloride was used mainly for ice control. Magnesium chloride brines were used for road dust and ice control.

Foreign Trade

Dead-burned and fused magnesia exports in 2010 were 3% higher than those in 2009. Canada (51%) was the principal destination. Caustic-calcined magnesia exports were 45% less than those in 2009. Mexico (48%) was the main destination (table 4).

Imports of dead-burned and fused magnesia were 113% higher than those in 2009, reflecting an increase in steel production; data reported by the World Steel Association (2011) indicated that U.S. steel production had increased by nearly 36% from 2009 to 2010. Imports of dead-burned and fused magnesia from China represented 66% of the total. Imports of caustic-calcined magnesia were slightly higher than those in 2009. China (43%) and Canada (24%) remained the principal sources (table 6).

Trade data for olivine are not available separately from the U.S. Census Bureau. The Journal of Commerce Port Import Export Reporting Service (PIERS) provides data on material that travels by ship. According to PIERS, U.S. exports of olivine in 2010 were 19 metric tons (t) to Mexico. U.S. olivine imports were 19,800 t; 98% came from Norway, and 2% came from China. Olivine was thought to be included in the Harmonized Tariff Schedule number for iron ore.

World Review

European Union.—In November, the European Union (EU) began a 15-month review of imports of magnesia refractory bricks from China after an antidumping ruling expired in September. The antidumping duties, which were established in 2005, ranged from 8.1% to 39.9%, applicable to the net free-at-Community-frontier price, depending upon the exporting company. The review request was made by the Magnesia Bricks Production Defence Coalition, which represented 25% of the EU's magnesia refractory brick manufacturers. The leading magnesia refractories manufacturer, Austria-based RHI AG, which was not a member of the coalition, did not support the duties. RHI had recently installed a new kiln at its subsidiary in Dalian, China (Industrial Minerals, 2010a).

Australia.—Queensland Magnesia Pty. Ltd. returned to full production capacity in June after running at about 25% of capacity since the beginning of 2009. The company also completed an expansion that increased its capacity by about 50% to bring the total to 175,000 t/yr of caustic-calcined magnesia, 135,000 t/yr of dead-burned magnesia, and 35,000 t/yr of fused magnesia (O'Driscoll, 2010g).

Beacon Hill Resources Plc received State government approval to develop its magnesite deposits in the Lyons River and Arthur River areas of northwestern Tasmania and, in the fourth quarter, began drilling to delineate the magnesite resource. As part of a 2011 work plan, the company planned to start additional drilling in the first quarter to develop a better understanding of the ore body and to produce additional core samples for metallurgical testing (Beacon Hill Resources Plc, 2010).

Brazil.—In August, Magnesita Refratários S.A. announced that it would increase production of dead-burned magnesia at its Contagem, Minas Gerais, plant by 2013. The expansion originally was announced in 2008, but because of the global economic downturn, it had not been initiated. Magnesita planned to increase capacity by 120,000 t/yr in two 60,000-t/yr increments. The first phase was estimated to cost $68.5 million and would involve installation of two furnaces and peripheral equipment (O'Driscoll, 2010b).

China.—China set its export quota for magnesia at 1.23 Mt for 2011. This was 8% lower than the 1.33 Mt quota in 2010 (O'Driscoll and Roberts, 2010).

India's Tata Refractories Ltd. announced that it would expand the production capacity at its TRL China magnesia refractories plant in Bayuquan to 90,000 t/yr from 54,000 t/yr. The expansion was scheduled to be completed by yearend. TRL China sold about 10% of its output locally, and the bulk of the refractory material produced there was exported to countries in Europe and Southeast Asia and to India. TRL China is owned 92% by Tata Refractories and 8% by Chinese firms (Industrial Minerals, 2010b).

Huayin Group Corp. expected to complete a 105,000-t/yr caustic-calcined magnesia plant in Tibet Autonomous Region by May 2011 and had plans to complete a second 250,000-t/yr plant by 2012. The first plant was being constructed to use fine-grained magnesite from the company's magnesite mine in Kamaduo, which opened in 2007. The caustic-calcined magnesia would be trucked and railed more than 3,000 kilometers to Huayin's Haicheng, Liaoning Province, facility, where it would be used as feedstock for fused magnesia and magnesia-spinel refractories production (O'Driscoll, 2010f).

Denmark (Greenland).—In February, Minelco A/S [a subsidiary of Swedish iron ore producer Luossavaara-Kiirunavaara AB (LKAB)] announced that it was closing its Seqi olivine mine in Seqinnersuusaaq, Greenland, by yearend. The 2-Mt/yr capacity mine, which had opened in 2005, was the second leading mine in terms of production capacity and represented nearly 25% of the global olivine production capacity, with most of the rest in Norway. Minelco cited unfavorable market conditions and low olivine prices as the reason for the closure (Roberts, 2010a). In June, LKAB announced that it had signed a long-term contract with Norway's North Cape Minerals A/S to supply the company's olivine requirements. North Cape had been the LKAB's olivine supplier until LKAB opened the Greenland mine (Roberts, 2010b).

India.—A new joint venture between National Mineral Development Co. Ltd. (74%) and J&K Minerals Ltd. (26%) planned to develop the Panthal magnesite deposit and build a 36,500-t/yr dead-burned magnesia plant at the site by August 2012. The deposit reportedly was estimated to contain 4.05 Mt of magnesite. The project was originally proposed in 1992, but because of the availability of low-cost imports of dead-burned magnesia from China, the deposit was not developed. The recent decline in availability of high-quality dead-burned magnesia from China prompted renewed interest in the deposit (O'Driscoll, 2010d).

Slovakia.—Russian firm Magnezit Group, which owned Slovmag a.s. Lubeník, one of Slovakia's two magnesite producers, planned to increase magnesia-based refractory brick production at the Lubenik plant. Slovmag had the capacity to produce 150,000 t/yr of magnesia-based bricks, and production was scheduled to increase by 25,000 t/yr of magnesia-carbon bricks, 15,000 t/yr of magnesia-chrome bricks, 10,000 t/yr of magnesia-spinel bricks, and 5,000 t/yr of magnesia bricks. The expansion was expected to be completed in 2011 (O'Driscoll, 2010c).

Spain.—Magnesitas Navarras S.A., Spain's leading magnesite producer, planned to open two new magnesite mines, which would extend the company's reserves by 30 years. The Borobia and Zilbeti Mines were scheduled to open in the first quarter of 2011 to replace the company's Azkarate Mine complex, which had reserves that were estimated to last only 6 to 7 years beyond 2010 at an extraction rate of 440,000 t/yr. The Borobia Mine reportedly had magnesite reserves of 50 Mt that would yield a finished product containing 88% MgO, and the Zilbeti Mine had 7 Mt of magnesite reserves that would yield a product containing greater than 65% MgO, with a low silica content. The company initially planned to extract 6 Mt from Borobia and 7 Mt from Zilbeti. Production from the new mines was expected to be 180,000 t/yr each (O'Driscoll, 2010e).

Turkey.—Trabzon Mining and Metal Corp., which had expected to have a 100,000-t/yr dead-burned magnesia plant onstream in Askale by the beginning of 2010, began producing test quantities at the end of 2010. The company expected to have commercial production available at the beginning of 2011 and planned to mine 280,000 t/yr of magnesite from eight open pit mines in the Erzurum and Erzincan regions. Trabzon Mining estimated that it owned 4.2 Mt of magnesite reserves in the open pit mining areas (O'Driscoll, 2010h).

In May, Kümaş Kütahya Manyezit İşletmeleri A.Ş. began production from a new 6,500-t/yr fused magnesia furnace, which doubled the company's fused magnesia production capacity. The company also planned to build a 25,000-t/yr dead-burned magnesia shaft kiln, which was expected to come onstream by early 2011. The expansions were in anticipation of reduced magnesia supplies from China (O'Driscoll, 2010a).

Outlook

According to the World Steel Association (2011), world crude steel output was 1.41 billion metric tons in 2010, a 15% increase from that in 2009 and a new world record for steel production. Production in the United States increased by nearly 36% compared with the low production level in 2009, indicating an improvement in the U.S. economy. Of the top 10 steel-producing countries, the largest percentage increase in production was in the United States. China continued to be the leading steel-producing nation, accounting for 44% of the global total in 2010, which was a 9.3% increase from production in 2009. A sustained increase in steel production in China could lead to more internal consumption of magnesia-based refractories, which could result in less magnesia available for the export market. China, however, has significant magnesite resources, particularly in Liaoning Province, and could continue to develop the magnesite deposits to satisfy domestic and export markets.

Because caustic-calcined magnesia is used in a wide variety of applications, the economic downturn did not affect consumption as significantly as consumption of refractory magnesia, which was directly tied to the performance of the U.S. steel industry. Increased use in water treatment (along with magnesium hydroxide) was expected to be the principal growth area for caustic-calcined magnesia.

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TABLE 1

SALIENT MAGNESIUM COMPOUND STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2006	2007	2008	2009	2010
United States:					
Caustic-calcined and specified magnesias:[2]					
Shipped by producers:[3]					
Quantity	133	125	170	147	162
Value	60,300	41,100	52,700	42,200	47,000
Exports[4]	6	4	1	1	(5)
Imports for consumption[4]	163	134	167	126	127
Refractory magnesia:					
Shipped by producers:					
Quantity	W	W	W	W	W
Value	W	W	W	W	W
Exports	20	22	22	8	9
Imports for consumption	433	437	386	151	323
World, production of magnesite	14,400 [r]	20,300 [r]	21,500 [r]	18,200 [r]	19,900 [e]

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Excludes caustic-calcined magnesia used in the production of refractory magnesia.

[3] Includes magnesia used by producers.

[4] Caustic-calcined magnesia only.

[5] Less than ½ unit.

TABLE 2

U.S. MAGNESIUM COMPOUND PRODUCERS, BY RAW MATERIAL SOURCE, LOCATION, AND PRODUCTION CAPACITY, IN 2010[1]

(Metric tons, MgO equivalent)

Raw material source and producing company	Location	Capacity	Products
Magnesite, Premier Magnesia LLC	Gabbs, NV	140,000	Caustic-calcined magnesia.
Lake brines:			
Great Salt Lake Minerals Corp.	Ogden, UT	185,000	Magnesium chloride and magnesium chloride brines.
Intrepid Wendover-Potash LLC	Wendover, UT	45,000	Magnesium chloride brines.
Well brines, Martin Marietta Magnesia Specialties LLC[2]	Manistee, MI	314,000	Caustic-calcined magnesia, dead-burned magnesia, and magnesium hydroxide.
Seawater:			
Premier Magnesia LLC	Port St. Joe, FL	107,000	Caustic-calcined magnesia and magnesium hydroxide.
South Bay Salt Works	Chula Vista, CA	3,000	Magnesium chloride brines.
SPI Pharma Inc.	Lewes, DE	5,000	Magnesium hydroxide.
Total		799,000	

[1] Data are rounded to no more than three significant digits; may not add to total shown.

[2] In addition to its Michigan plant, Martin Marietta owned a 15,000-metric-ton-per-year-capacity magnesium hydroxide plant in Lenoir City, TN, which used imported magnesite as a raw material.

TABLE 3

U.S. MAGNESIUM COMPOUNDS SHIPPED AND USED[1]

	2009		2010	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Caustic-calcined and specified (USP and technical) magnesias[2]	147,000	\$42,200	162,000	\$47,000
Magnesium hydroxide [100% $Mg(OH)_2$][2]	166,000 r	104,000	171,000	107,000
Magnesium sulfate, anhydrous and hydrous	40,100	11,600 r	47,400	20,600
Refractory magnesia	W	W	W	W

r Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.

TABLE 4

U.S. EXPORTS OF CRUDE AND PROCESSED MAGNESITE, BY COUNTRY[1]

Material and country	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Caustic-calcined magnesia:				
China	81	$41	94	$57
India	--	--	27	21
Mexico	57	29	134	76
Thailand	351	178	--	--
Other	14	48	23	11
Total	503	296	278	165
Dead-burned and fused magnesia:				
Canada	5,580	3,420	4,380	2,780
China	697	517	88	127
Germany	120	113	540	502
Hong Kong	140	114	59	75
India	226	214	65	59
Mexico	435	429	217	380
South Africa	30	18	839	461
Taiwan	40	36	155	169
United Kingdom	57	62	150	249
Venezuela	124	144	1,020	592
Other	940 [r]	891 [r]	1,140	1,150
Total	8,390	5,950	8,650	6,550
Other magnesia:				
Brazil	858	959	1,420	1,520
Canada	2,600	2,510	2,730	3,000
France	1,170	1,050	1,580	1,450
Germany	798	634	934	903
India	275	275	576	544
Korea, Republic of	1,770	1,420	767	685
Mexico	1,100	1,360	590	1,040
Netherlands	684	563	2,610	2,040
Taiwan	1,280	1,230	1,950	1,650
Other	2,130 [r]	3,530 [r]	4,910	7,450
Total	12,700	13,500	18,100	20,300
Crude magnesite:				
Argentina	43	6	382	50
Canada	3,020	499	2,340	414
China	205	28	--	--
Egypt	153	20	736	97
France	2,810	370	--	--
Germany	651	85	792	104
Italy	760	84	614	80
Netherlands	945	124	461	60
Saudi Arabia	497	65	963	126
Sweden	--	--	536	105
United Kingdom	679	89	337	44
Other	707 [r]	108 [r]	1,760	234
Total	10,500	1,480	8,920	1,310

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5

U.S. EXPORTS OF MAGNESIUM COMPOUNDS[1]

Material	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)	Principal destinations in 2010
Magnesium chloride, anhydrous and other	7,780	$5,480	8,030	$6,260	Canada, 84%; Italy, 8%.
Magnesium hydroxide and peroxide	19,100	17,500	16,700	13,800	Canada, 66%; Mexico, 8%.
Magnesium sulfate, natural kieserite and epsom salts	207	311	255	265	Saudi Arabia, 56%; Mexico, 16%; Canada, 12%.
Magnesium sulfate, other	10,600	5,000	9,920	4,810	Canada, 94%; Mexico, 4%.

[1] Data are rounded to no more than three significant digits.

Source: U.S. Census Bureau.

TABLE 6

U.S. IMPORTS FOR CONSUMPTION OF CRUDE AND PROCESSED MAGNESITE, BY COUNTRY[1]

Material and country	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Caustic-calcined magnesia:				
Australia	5,070	$1,490	14,900	$4,130
Brazil	15,400	3,770	11,800	3,270
Canada	26,300	11,000	30,400	13,100
China	79,000	21,300	55,000	14,000
Hong Kong	--	--	7,930	2,530
Spain	--	--	3,800	1,220
Turkey	--	--	2,110	1,290
United Kingdom	136	140	168	179
Other	25[r]	27[r]	1,280	588
Total	126,000	37,700	127,000	40,300
Dead-burned and fused magnesia:				
Australia	650	250	42,300	17,600
Austria	21,200	12,300	2,920	1,250
Brazil	22,200	7,690	26,600	8,100
China	96,900	34,200	213,000	99,000
Germany	14	38	3,110	2,630
Greece	101	44	6,760	2,580
Israel	3,530	10,500	4,140	11,900
Japan	2,380	5,060	2,210	4,900
Mexico	1,160	690	6,710	3,750
Russia	60	12	10,800	3,970
Spain	2,000	644	3,950	1,290
Other	1,080[r]	776[r]	645	3,960
Total	151,000	72,200	323,000	161,000
Other magnesia:				
Brazil	179	272	646	3,310
Canada	552	326	564	328
China	467	760	427	499
Israel	374	802	558	1,310
Japan	569	1,430	1,000	2,570
Mexico	5,160	3,650	4,090	3,450
Slovakia	1,070	370	1,670	549
Spain	119	63	2,740	1,310
Other	242[r]	1,080[r]	265	1,220
Total	8,740	8,750	12,000	14,500
Crude magnesite:				
Brazil	209	221	516	414
China	3,330	472	9,980	2,130
France	208	184	240	219
Hong Kong	--	--	8,400	2,550
Israel	1,690	1,580	1,540	1,380
Japan	472	1,130	254	482
United Kingdom	176	186	1,130	1,010
Other	184	59	350	238
Total	6,270	3,830	22,400	8,420

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF MAGNESIUM COMPOUNDS[1]

	2009		2010		
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Principal sources in 2010
Magnesium chloride, anhydrous and other	88,000	$21,500	87,900	$24,100	Israel, 73%; Netherlands, 24%.
Magnesium hydroxide and peroxide	2,930	6,440	5,500	13,900	Israel, 28%; Austria, 22%; Mexico, 15%.
Magnesium sulfate, natural epsom salts	1,740	378	3,340	780	China, 72%; India, 26%.
Magnesium sulfate, natural kieserite	25,800	574	5,900	134	Germany, 100%.
Magnesium sulfate, other	15,000	9,660	19,000	10,100	China, 44%; Germany, 36%.

[1] Data are rounded to no more than three significant digits.

Source: U.S. Census Bureau.

TABLE 8
WORLD MAGNESIUM COMPOUNDS ANNUAL PRODUCTION CAPACITY, DECEMBER 31, 2010[1,2]

(Thousand metric tons, MgO equivalent)

	Raw material				
	Magnesite		Seawater or brines		
Country	Caustic-calcined	Dead-burned	Caustic-calcined	Dead-burned	Total
Australia	218	110	--	--	328
Austria	76	325	--	--	401
Brazil	96	320	12	--	428
Canada	100	--	--	--	100
China	1,440	2,740	--	--	4,180
France	--	--	30	--	30
Greece	200	100	--	--	300
India	20	202	--	--	222
Iran	25	40	--	--	65
Ireland	--	--	--	90	90
Israel	--	--	10	60	70
Italy	25	--	--	--	25
Japan	--	--	50	70	120
Jordan	--	--	10	50	60
Korea, North	25	100	--	--	125
Korea, Republic of	--	--	--	40	40
Mexico	--	--	15	95	110
Netherlands	--	--	10	165	175
Norway	--	--	30	--	30
Poland	--	10	--	--	10
Russia	150	2,400	--	--	2,550
Serbia	--	40	--	--	40
Slovakia	--	465	--	--	465
South Africa	12	--	--	--	12
Spain	150	70	--	--	220
Turkey	33	404	--	--	437
Ukraine	--	120	20	80	220
United States	140	--	191	195	526
Total	2,710	7,450	378	845	11,400

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes capacity at operating plants, as well as at plants on standby basis.

TABLE 9
MAGNESITE: WORLD PRODUCTION, BY COUNTRY[1,2]

(Metric tons)

Country	2006	2007	2008	2009	2010[e]
Australia	446,000	447,000	126,000	344,000 [r]	300,000
Austria, crude	769,188	811,556	837,476	544,716 [r]	700,000
Brazil, beneficiated	382,718	399,314	421,333 [r]	400,000	400,000 [p]
Canada[e, 3]	140,000 [r]	140,000 [r]	140,000 [r]	140,000 [r]	150,000
China[e]	6,700,000	14,000,000 [r]	15,600,000 [r]	13,000,000 [r]	14,000,000
Colombia[e]	40,000	42,000	38,000	-- [r]	--
Greece, crude	463,277	351,414	361,165	250,234 [r]	300,000
Guatemala	1,084	7,612	11,758	17,247 [4]	17,500
India[e]	370,000	360,000	350,000	340,000	330,000
Iran	110,000	112,229 [r, 4]	115,987 [r, 4]	115,000 [e]	115,000
Korea, North[e]	60,000 [r]	55,000 [r]	150,000 [r]	150,000 [r]	150,000
Pakistan	1,884	2,370 [r]	1,600 [e]	2,000 [r]	1,800
Poland, concentrate	62,500	65,000	60,000 [r, e]	47,000 [r]	50,000
Russia[e]	1,200,000	1,200,000	1,200,000	1,000,000	1,200,000
Serbia, crude[e]	20,000	20,000	20,000	20,000	20,000
Slovakia, concentrate	941,000	957,000	807,000	478,000 [r]	650,100 [4]
South Africa	73,300	80,700	83,900	75,000 [r, e]	80,000
Spain	539,239	461,901	460,000 [e]	460,000	460,000
Turkey, run-of-mine	2,088,033	802,406 [r]	677,784 [r]	861,180 [r]	1,000,000
United States	W	W	W	W	W
Zimbabwe	939	1,814 [r]	2,549 [r]	449 [r]	500
Total	14,400,000 [r]	20,300,000 [r]	21,500,000 [r]	18,200,000 [r]	19,900,000

[e] Estimated. [p] Preliminary. [r] Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Figures represent crude salable magnesite. In addition to the countries listed, Bulgaria produced magnesite, but output is not reported quantitatively, and available information is inadequate for formation of reliable estimates of output levels. Table includes data available through May 11, 2011.

[3] Magnesitic dolomite and brucite.

[4] Reported figure.

MANGANESE

By Lisa A. Corathers

Domestic survey data and tables were prepared by Connie Lopez, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2010, U.S. manganese apparent consumption was estimated to be 758,000 metric tons (t), a 68% increase from the revised amount of 451,000 t in 2009 (table 1). Increases in imports of manganese dioxide, manganese ferroalloys, manganese metal, and manganese ore, as well as a slight increase in high-carbon ferromanganese shipments from the U.S. Government's National Defense Stockpile (NDS), accounted for the rise in apparent consumption.

Manganese exports decreased by 21% to 37,300 t compared with those of 2009, based on the typical manganese contents of the materials as calculated in table 4. Manganese imports increased by 93% on a content basis to 758,000 t compared with those of 2009, based on U.S. Census data for manganese ore, ferromanganese, and silicomanganese, and the stochiometric ratios for manganese dioxide and manganese metal.

In 2010, the annual average domestic price of ore increased by 15% from that in 2009 (revised). The annual average international benchmark price of metallurgical-grade ore increased by 11%, based on quarterly contract prices between Australian producers and Japanese consumers in 2010. Average U.S. spot-market prices for high- and medium-carbon ferromanganese and silicomanganese increased from those in 2009 by 16%, 28%, and 27%, respectively (table 1). The average spot market price for manganese metal increased by 16% from that in 2009.

Only high-carbon ferromanganese remained in NDS physical inventory at yearend 2010. Sales of manganese materials from the NDS in 2010 reduced the Government's inventory of manganese by 9% (content basis), leaving an inventory that was 20% more than the amount of high-carbon ferromanganese reported consumed on a contained-weight basis in 2010.

World production of manganese ore in 2010 increased by 26% on a gross-weight basis and by 31% on a contained-weight basis, compared with that in 2009. China was the leading producer of manganese ore (table 8). Combined world production of ferromanganese and silicomanganese increased by 16% to 15.2 million metric tons (Mt) on a gross-weight basis compared with the revised amount in 2009 (table 9). China was the leading producer of these manganese ferroalloys.

Manganese is essential to iron and steel production by virtue of its sulfur-fixing, deoxidizing, and alloying properties. Steelmaking, including its ironmaking component, accounted for most of the reported domestic manganese consumption, currently in the range of 77% to 90% of U.S. apparent consumption. Among a variety of other uses, manganese is a key component of certain widely used aluminum alloys and is used in oxide form in dry cell batteries.

Legislation and Government Programs

Air Quality, Emissions Limits.—The U.S. Environmental Protection Agency (EPA) issued final national emission standards for hazardous air pollutants (HAPs) for prepared animal feeds (except cat and dog) manufacturing in which manganese compounds are added to products. The emission standards involve various housekeeping, monitoring, and recordkeeping requirements for the storage, use, and handling of manganese materials, including the use of dust control devices at bulk loading areas and in pelletizing operations (U.S. Environmental Protection Agency, 2010c, p. 546–550).

Air Quality, Public Health Study.—The EPA conducted air sampling from August 17, 2009, through November 15, 2009, at three schools in Ohio and West Virginia to determine potential health impacts from air emissions around Eramet Marietta, Inc.'s manganese ferroalloy facility. Elevated levels of manganese were detected at each school, although they posed no immediate health threat. The EPA planned to conduct additional air monitoring in the summer of 2011 to determine whether there were long-term health concerns. Eramet Marietta indicated that it would replace the emission control device on one of their furnaces to reduce particulate matter emissions, which would result in reduced airborne manganese (U.S. Environmental Protection Agency, 2010b, f).

Toxic Substances Control Act, Significant New Use Rules (SNUR).—In September, the EPA issued a direct final rule that required 90-day premanufacture notices (PMNs) for several manganese materials, including cobalt-lithium-manganese-nickel oxide used as battery cathode material, styrenyl-surface-treated manganese ferrite used to manufacture polymerized pigments, and styrenyl-surface-treated manganese ferrite with acrylic ester polymer used to manufacture electronic inks. In addition to manufacturing, the PMNs also apply to importers and processors of these materials. The PMNs would allow the EPA to evaluate the intended use and, if necessary, prohibit or limit that activity before it took place. On November 18, the EPA withdrew the SNUR for cobalt-lithium-manganese-nickel oxide and proposed a new one (U.S. Environmental Protection Agency, 2010a, d, e, p. 57172, 57177).

Toxicological Profile for Manganese.—The Agency for Toxic Substances and Disease Registry of the U.S. Department of Health and Human Services retained the chronic-duration inhalation minimal risk level of 0.04 microgram of manganese per cubic meter as it continued to update the toxicological profile for manganese that was last published in 2000 (Agency for Toxic Substances and Disease Registry, 2010).

Stockpile.—The Annual Materials Plan (AMP) for fiscal year 2010 that the Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center) issued on October 1, 2009, covered the period from October 1, 2009, through September 30, 2010. Under this AMP, the maximum disposal authority for manganese materials was 90,718 t each for metallurgical-grade ore and high-carbon ferromanganese (Defense National Stockpile Center, 2009). The maximum disposal authority under an AMP is the maximum quantity of material that may be disposed in a given fiscal year as authorized by Congress; these may differ from the disposal authority quantities listed in table 2.

For calendar year 2010, the DLA disposed of (sold) 34,473 t of high-carbon ferromanganese. Only high-carbon ferromanganese remained in the NDS physical inventory at yearend (368,000 t, gross weight). The estimated manganese content of this material was 276,000 t, which was about 9% less than the amount contained at yearend 2009. Sales of ferromanganese were curtailed to hold a goal quantity equivalent to 1 year's AMP (U.S. Department of Defense, 2011, p. 8).

Exploration and Development

American Manganese Inc. (formerly Rocher Deboule Minerals Corp.) (White Rock, British Columbia, Canada) completed a new National Instrument (NI) 43–101 resource study estimate of its Artillery Peak manganese project (Mohave County, AZ). Indicated resources were 92.8 Mt at an average grade of 3.27% manganese (above a 0.90% manganese cutoff grade) and 80.7 Mt at an average grade of 3.55% (above a 1.30% manganese cutoff grade). Inferred resources were 107.2 Mt at an average grade of 3.76% (above a 0.90% manganese cutoff grade) and 84.1 Mt at an average grade of 4.13% (above a 1.30% manganese cutoff grade). These were substantially higher than 10.9 Mt at an average grade of 4.46%, and inferred resources were 96.9 Mt at an average grade of 4.52% assessed in 2009. A processing rate of 3,500 metric tons per day was expected to yield about 49,000 metric tons per year (t/yr) of electrolytic manganese metal based on mill feed containing 4.5% manganese and having an overall 90% rate of recovery. The metal would be produced using a patent-pending sulfurous acid-leach process followed by conventional electrolysis. No roasting or calcining of the mill feed would be required (American Manganese, Inc, 2010a, b).

Wildcat Silver Corp. (Vancouver, British Columbia, Canada) completed an updated preliminary economic assessment of its Hardshell silver-manganese-copper-zinc-lead project (now known as the Hermosa project) in Santa Cruz County, AZ. The company planned to initially mine the area via open pit, with underground operations starting 4 years after startup. Indicated manganese resources were 410,000 t at an average grade of 6.83% manganese and inferred manganese resources were 3.4 Mt at an average grade of 7.44% manganese. A processing plant would use a sulfuric acid leach process followed by copper precipitation, zinc solvent extraction-electrowinning, and manganese and silver recovery circuits. An average of 233,000 t/yr of manganese carbonate was expected to be produced for 18 years (Wildcat Silver Corp., 2010a, b).

Production

Ore and Concentrate.—The only mine production of manganese in the United States consisted of small amounts of manganiferous material having a manganese content of less than 5%. This material was produced in South Carolina for use in coloring brick.

Chemicals, Ferroalloys, and Metal.—Production statistics for these materials were withheld to avoid disclosing company proprietary data. Domestic producers of manganese ferroalloys, metal, and synthetic dioxide are listed in table 3.

Several events affected production of refined ferromanganese and silicomanganese in the United States in 2010. At its Marietta, OH, ferroalloys plant, Eramet Marietta declared force majeure for silicomanganese from March through September after its No. 18 refined ferromanganese furnace was damaged and taken offline when a buildup of pressure blew material off its top. The company switched silicomanganese production in its No. 1 furnace to high-carbon ferromanganese for refining into medium- and low-carbon ferromanganese. In June, refurbishment of the No. 12 high-carbon furnace that started in 2009 was completed. By yearend, the No. 12 furnace was again producing ferromanganese and the No. 1 furnace, silicomanganese (Metal-Pages, 2010e; Platts Metals Week, 2010). However, Felman Production Inc. was able to produce silicomanganese steadily throughout the year. On March 2, Eramet Marietta reached a 3-year labor agreement with unionized workers. It was the first new contract at the company since a 5-month lockout ended in early 2007 (Metal-Pages, 2010c).

Consumption, Uses, and Stocks

In 2010, U.S. manganese apparent consumption was estimated to be 758,000 t (table 1). Metallurgical applications account for most domestic manganese consumption, 77% to 90% of which has been for steelmaking. Reported consumption (gross weight) of ferromanganese, manganese metal, and silicomanganese increased by 21%, 10%, and 4%, respectively, from that in 2009 (table 4). Because of incomplete reporting to the U.S. Geological Survey (USGS) voluntary consumption survey, the figures in this table represent relative rather than absolute quantities.

Based on the apparent consumption of ferromanganese, manganese metal, and silicomanganese, on a gross-weight basis, manganese alloy unit consumption in steelmaking was about 7.5 kilograms per metric ton (kg/t) or about 1.91 times the reported consumption in 2010. This level was 60% more than the revised quantity of 4.7 kg/t estimated for 2009 and was predominantly a result of significant increases in ferromanganese and silicomanganese apparent consumption. The increase in the apparent consumption of these ferroalloys was attributable to significant increases in imports.

Relatively small quantities of manganese were used for alloying with nonferrous metals, chiefly in the aluminum industry as manganese-aluminum briquettes that typically contained either 75% or 85% manganese. Manganese plays an important alloying role in aluminum to increase corrosion resistance. The most important use of aluminum-manganese alloys is in the manufacture of beverage cans. Other uses include, but are not limited to, aircraft, automobiles, cookware, radiators, and roofing (Roskill Information Services Ltd., 2008, p. 195, 200).

Comparatively small amounts of manganese were used domestically in animal feed, brick coloring, dry cell batteries, fertilizers, and manganese chemicals. These were among the many nonmetallurgical applications of manganese (Roskill Information Services Ltd., 2008, p. 206–229). The source of manganese units for these applications was mainly manganese ore.

In 2010, reported domestic consumption of manganese ore increased by 11% to 468,000 t, while corresponding yearend stocks decreased by 22% to 89,100 t, compared with the amounts in 2009 (table 1). Apparent consumption of manganese ore on a gross-weight basis in 2010 was about 501,000 t, which excluded any manganese ore consumed directly by ironmaking and steelmaking plants. The USGS excludes reporting by these operations to avoid disclosing company proprietary information. The discrepancy between apparent and reported consumption represented incomplete reporting to the USGS voluntary consumption survey.

Data on domestic consumption of manganese ore, exclusive of that consumed by the steel industry, are collected by means of the "Manganese Ore and Products" survey. In 2010, eight firms were canvassed that process ore or had processed ore in the past by such methods as grinding and roasting, or that consume it in the manufacture of dry cell batteries and manganese chemicals, ferroalloys, and metals. Of those eight companies, all consumed manganese ore in their processes in 2010. The collective consumption of these firms was considered to constitute all the manganese ore consumption in the United States, exclusive of that consumed by the steel industry. Full-year responses or a basis upon which to estimate the data were obtained from all of these firms for 2010.

Prices

There were significant increases in annual average manganese material prices in 2010 from those in 2009 because of improved global economic conditions.

Manganese Ore.—The USGS estimated the annual U.S. average contract price of metallurgical-grade ore containing 46% to 48% manganese was $9.18 per metric ton unit (mtu). This was a 15% increase compared with that in 2009, which followed the 11% increase in the annual average international benchmark price for this grade of ore, as calculated from quarterly contract prices set between Japanese consumers and Australian producers (Australian Bureau of Agricultural and Resource Economics and Sciences, 2011, p. 28). The international benchmark price for the first time reflected cost, insurance, and freight rather than the historical free-on-board (f.o.b.) charges (TEX Report, The, 2010). The 2010 average spot market price for this grade of ore based on weekly averages of Chinese cost and freight (CNF) transaction prices as reported by Ryan's Notes was $7.23 per mtu. The range in CNF spot market prices per mtu peaked in May at $8.50 to $8.90 and then trended downwards to finish the year at $6.50 to $6.80 per mtu because of increased world mine capacity and high manganese ore inventories at Chinese ports, which were reported to be more than 2.5 Mt (Metal-Pages, 2010a). The price of 1 metric ton of ore (gross weight) is obtained by multiplying the mtu price by the percentage manganese content of the ore; for example, by 48 when the manganese content is 48%. The ore market consisted of a number of submarkets because of differences in ore-quality requirements by end use—ferroalloy production, blast furnace ironmaking, and manufacture of manganese chemicals.

Manganese Ferroalloys and Metal.—Prices for manganese ferroalloys tend to vary in response to changes in demand by the steel and ferrous foundry industries, while those of manganese metal predominantly follow changes in demand by the aluminum industry. Manganese ferroalloy prices are also influenced by changes in the product mix of the world's suppliers because different manganese ferroalloys are largely interchangeable with each other.

Annual average import prices for manganese ferroalloys are given by Platts Metals Week. These prices are based on free market spot prices per unit of measurement, f.o.b. Chicago, IL, or Pittsburgh, PA, warehouse. Annual average import prices were $1,403.41 per gross (long) ton for high-carbon ferromanganese, 129.09 cents per pound for medium-carbon ferromanganese, and 64.27 cents per pound for silicomanganese. These prices were 16%, 28%, and 27% higher, respectively, than those of 2009. The annual average price for manganese metal is based on weekly averages of North American transaction prices published by Ryan's Notes for bulk shipments of manganese metal, f.o.b. Chicago, IL, or Pittsburgh, PA, warehouse. The annual average North American transaction price for manganese metal was 162.60 cents per pound, which was a 16% increase compared with that of 2009.

According to Platts Metals Week, the price range for high-carbon ferromanganese containing 78% manganese, per gross ton, began the year at $1,310 to $1,350 and ended the year at $1,300 to $1,350, for a slight net decrease. The price range, per pound of manganese, for medium-carbon ferromanganese with a manganese content of 80% to 85% and a nominal carbon content of 1.5% began the year at 105 to 109 cents and ended the year at 117 to 119 cents, for a net increase of 10%. The price range, per pound of alloy, for imported silicomanganese with 2% carbon started the year at 58 to 62 cents and ended 2010 at 59 to 62 cents, for a slight net increase. The net price increases for medium-carbon ferromanganese and silicomanganese were caused by supply concerns when U.S. producer Eramet Marietta declared a force majeure on manganese alloys production in March and early April.

According to Ryan's Notes North American transaction prices, the 2010 yearend price range of bulk manganese metal shipments was 182.5 to 187.5 cents per pound, a net increase of 27% from the price of 142 to 150 cents per pound at the beginning of the year. This net price increase was attributable to rising costs of Chinese manganese metal exports.

Foreign Trade

In the absence of domestic mine production and recycling for manganese, U.S. net import reliance, as a percentage of apparent consumption, was 100% for manganese, the same as it has been for the past 25 years. The ensuing comparisons of foreign trade data were made on the basis of gross weight.

In 2010, U.S. exports of manganese dioxide and manganese metal increased, while exports of ferromanganese, manganese ore, and silicomanganese decreased compared with exports of these materials for 2009 (table 5). The biggest year-to-year change in exports was that of silicomanganese, which were 50% lower than those in 2009. Mexico accounted for 54% of U.S. silicomanganese exports, followed by Canada with 23%.

In 2010, U.S. imports of ferromanganese, manganese dioxide, manganese metal, manganese ore, and silicomanganese increased compared with those of 2009, while imports of potassium permanganate decreased (table 6). The most significant year-to-year change was for imports of manganese ore, which were 43% more than those of 2009. Increases in this import category were especially notable for China, with an increase of 95,400 t, up from zero in 2009; and for Gabon and Australia, with year-on-year increases of 60,100 t (32%) and 50,800 t (142%), respectively.

Antidumping Duty Administrative Reviews.—Final antidumping duty rates assessed in 2010 on imports of manganese materials to the United States are summarized in table 7.

U.S. World Trade Organization (WTO) Chinese Raw Material Export Dispute Settlement Proceedings.—On March 29, panel representatives were appointed to the WTO Dispute Settlement Body (DSB) that was formed in response to requests from the United States, the European Union, and Mexico, regarding curbs placed by China in 2009 on exports of various materials, including a tax of 20% on ferromanganese, manganese metal, and silicomanganese exports and a 15% tax on manganese ore exports. The DSB panel was expected to finalize its determination in April 2011, although as of June 30, 2011, it had not done so (Office of the United States Trade Representative, 2009; American Metal Market, 2010; World Trade Organization Dispute Settlement Body, 2010).

World Industry Structure

World manganese ore production was estimated by the USGS to be 14.2 Mt (contained manganese) in 2010, up 31% from the revised amount in 2009. Most (95%) manganese ore was produced in 10 countries. On a manganese-content basis, the leading producer countries of manganese ore were Australia (21%), South Africa (20%), China (18%), Gabon (10%), and India (7%) (table 8). World manganese ferroalloy production was estimated by the USGS to be 15.2 Mt (gross weight) in 2010, an increase of 16% compared with the revised amount in 2009. On a gross weight basis, the leading producer countries of manganese ferroalloys were China (55%), India (9%), Ukraine (8%), South Africa (5%), Norway (4%), and Japan (3%) (table 9).

CRU International Ltd. estimated that world consumption of manganese ferroalloys increased by 25% to 15.1 Mt in 2010 compared with that of 2009. Of that amount, 9.3 Mt was silicomanganese, 4.4 Mt was high-carbon ferromanganese, and 1.4 Mt was refined (medium- and low-carbon) ferromanganese. World consumption was slightly more than CRU's estimate of world manganese ferroalloys production in 2010 (15 Mt). The International Manganese Institute (IMnI) estimated world manganese ore production to be 14.1 Mt (contained manganese), which was an increase of 33% from the IMnI estimate of 11.1 Mt in 2009 (CRU Bulk Ferroalloys Monitor, 2011; Mark Camaj, market analyst, International Manganese Institute, unpub. data, May 26, 2011).

World Review

New manganese materials projects scheduled for completion around the world from 2010 through 2014 are listed in table 10. In 2010 alone, an additional 2.3 million metric tons per year (Mt/yr) of manganese ore and 262,000 t/yr of manganese ferroalloys capacity were planned. Additional manganese mine capacity was in South Africa (1.25 Mt/yr), Namibia (480,000 t/yr), Australia (440,000 t/yr), Burkina Faso (50,000 t/yr), and Zambia (48,000 t/yr). New manganese ferroalloys capacity was in China (120,000 t/yr of silicomanganese), South Africa (75,000 t/yr of high-carbon ferromanganese), and India (67,000 t/yr of ferromanganese and silicomanganese).

Brazil.—Vale S.A. was the leading manganese ore and ferroalloy producer in Brazil. Vale produced 1.8 Mt of manganese ore in 2010, an increase of 11% from that of 2009. The Azul Mine in the Carajás region produced 1.6 Mt of ore. Vale's manganese ferroalloys plants, with the exception of the Urucum plant, produced 207,000 t, more than double that in 2009 (Vale S.A., 2011, p. 4).

China.—Chinese imports of manganese ore were at an alltime high of 11.6 Mt (gross weight) in 2010, up 21% from those of 2009 (TEX Report, The, 2011a). This was about 27% of the USGS estimated total world production (gross weight) in 2010. The leading sources of Chinese manganese ore imports were Australia (3.16 Mt), South Africa (3.11 Mt), Gabon (1.30 Mt), Brazil (1.25 Mt), and Burma (0.75 Mt). Most of the imported manganese ore likely was blended with lower-grade domestic manganese ore for the production of manganese ferroalloys and metal.

China was the leading producer of manganese ferroalloys in the world, but it still relied on imports of ferromanganese and silicomanganese. The country exported 15% more ferromanganese in 2010 (54,000 t) than it did in 2009, but it exported significantly less silicomanganese (72,000 t, -37%) (TEX Report, The, 2011b).

China, the leading producer of electrolytic manganese metal (EMM) in the world with about 188 companies, produced 1.38 Mt of EMM in 2010, an increase of 7% from that in 2009. The country exported about 220,000 t of EMM in 2010, an increase of 42% from that in 2009. China's EMM capacity in 2010 was estimated to be 2.2 Mt/yr, or 98% of the world total. The country's EMM capacity utilization rate in 2010 was about 62% (TEX Report, The, 2011c; Xie, 2011, p. 9). In 2010, the Chinese Ministry of Industry and Information Technology began evaluating the elimination of EMM plants with production lines of less than 5,000 t/yr capacity and plants that were noncompliant with environmental requirements. As a result, the country's EMM production capacity would be reduced by 2012 to between 1.5 Mt/yr and 1.7 Mt/yr by 2012 (JF Zhang Associates Inc., 2011, p. 67).

In 2010, China was also the leading producer of EMD in the world, with total output of 202,000 t. This equated to 77% of the country's annual production capacity held by 14 producers, which was 260,000 t. China's share of the active world EMD production capacity in 2010 was about 62%, followed by the United States with 15%. Other countries with EMD capacity include Colombia, Greece, India, Japan, South Africa, and

Spain. China's EMD exports increased to 48,000 t in 2010 from 38,700 t in 2009 (Li, 2011, p. 27).

CITIC Dameng Holdings Ltd. (2010, p. 102, 104) summarized the Government's requirements for new EMM and manganese alloy producers in China in its initial public offering prospectus. The minimum capacity for each new EMM production line was 10,000 t/yr. The minimum production capacities for new ferromanganese blast furnaces and silicomanganese electric arc furnaces (EAFs) were 70,000 t/yr (300 cubic meters) and 40,000 t/yr [25,000-kilovoltampere (kVA)], respectively, except for silicomanganese EAFs in midwest China, which must have at least 20,000 t/yr (12,500 kVA) production capacity. CITIC also noted that the Government has compiled lists of outdated existing ferroalloy production facilities that would be shut down "in the near-term" to meet its industrial policies. If fully carried out, these policies were expected to affect 755 ferroalloy producers and eliminate about 4 Mt/yr of outdated ferroalloy production capacity, including 1.3 Mt/yr of silicomanganese capacity.

Starting July 15, the Central Government revoked the 5% value-added-tax rebate on exports of wrought manganese products categorized under the Harmonized Tariff Schedule (HTS) code 8111.00.6000. The Government maintained the 20% export duty on ferromanganese, unwrought manganese metal (except manganese briquettes), and silicomanganese exports. It also kept the duty on manganese ore exports at 15% (Metal-Pages, 2009, 2010b; Swire, 2009).

France.—Eramet SA reported a 26% reduction in worldwide manganese alloy output in 2010 to 779,000 t compared with that in 2009. The company owned manganese alloy plants in China, France, Norway, and the United States (Eramet SA, 2011, p. 34). Vale's Rio Doce Manganese Europe tripled manganese alloy production at its Dunkerque plant to 138,000 t in 2010 from that in 2009 (Vale S.A., 2011, p. 4).

Gabon.—Eramet reached an agreement with the Government of Gabon that would increase the Government's share of the Compagnie Miniere de l'Ogoouse (Comilog) S.A. mine by 10% to 35.4% (Eramet SA, 2011, p. 32).

Macedonia.—In April, Skopski Leguri DOOEL restarted one furnace at its manganese ferroalloys plant in Skopje after a 5-month stoppage. The company would produce either ferromanganese or silicomanganese depending on customer requirements (Metal-Pages, 2010d).

Norway.—Eramet relined the Nos. 1 and 10 manganese ferroalloy furnaces at Kvinesdal and Porsgrunn, respectively, with refractory during the year (Eramet SA, 2011, p. 11). Manganese ferroalloy production at Vale's Mo I Rana plant was 106,000 t, a 34% increase from that of 2009 (Vale, S.A., 2011, p. 4).

South Africa.—In May, Samancor Manganese sold its 51% equity stake in Manganese Metal Company (Pty.) Ltd. (MMC) to Agattu Trading 195 (Pty.) Ltd. Also in May, U.S.-based Valmont Industries, Inc. acquired a 56% share in Delta EMD Ltd., which owned the remaining 49% of MMC. Delta EMD's ownership in MMC was transferred to Valmont (BHP Billiton Ltd., 2010, p. 46; Valmont Industries, Inc., 2012).

South African manganese producers were facing rail and port infrastructure constraints as substantial additions of manganese ore production capacity were planned through 2014 (table 10). Transnet SOC Ltd., South Africa's state-run port and rail utility began evaluating options for expanding manganese rail line and shipping port capacities. Transnet was responsible for transporting manganese ores from mines located in the Kalahari Basin in the Northern Cape region by bulk rail to the Port Elizabeth and Durban. In 2010, the manganese ore terminal capacity at Port Elizabeth was 5.5 Mt/yr and at Durban, 1 Mt/yr. Transnet's rail capacity to Durban matched that of the port, but rail capacity to Port Elizabeth was only 4.2 Mt/yr. As an interim solution, Transnet planned to increase its Port Elizabeth rail line capacity to 5.5 Mt/yr by July 2012, while continuing to evaluate whether to locate a new 12-Mt/yr manganese facility at Port Ngqura or Port Saldanha by 2016–17. The manganese terminal at Port Elizabeth would then be vacated (Herbert, 2011, p. 12, 18, 29–30).

Ukraine.—Ukraine's total output of manganese concentrate increased by 71% in 2010 to 1.59 Mt, compared with that of 2009. Manganese ferroalloy production also increased in 2010 by 120% for ferromanganese, 27% for silicomanganese, and 4% for electrothermic manganese metal. Nikopol Ferroalloy Plant's produced 704,600 t of silicomanganese and 210,600 t of ferromanganese, up 21% and 170%, respectively. OAO Zaporozhsky Ferro-Alloy Works produced 152,100 t of silicomanganese, 69,500 t of ferromanganese, and 15,700 t of electrothermic manganese metal, up 32%, 32%, and 4%, respectively, from those in 2009. Silicomanganese production at the Stakhanov Ferroalloy Plant increased to 83,700 t, which was a 91% increase from that in 2009 (Interfax Russia & CIS Metals and Mining Weekly, 2011).

Outlook

The trend of domestic and global consumption for manganese is expected to follow closely that of steel production, for which the annual growth rate in the United States has been typically in the range of 1% to 2%. Although growth rates for some nonmetallurgical components of manganese consumption, especially batteries, may be higher than for steel production, this situation should have only a minor effect on overall manganese demand.

Details of the outlook for the steel industry are discussed in the Outlook section of the Iron and Steel chapter of the 2010 USGS Minerals Yearbook, volume I, Metals and Minerals. According to the World Steel Association (2011), raw steel production, compared with that in 2009, increased by 38.5% to 80.6 Mt in the United States and by 15% worldwide to slightly more than 1.4 billion metric tons (Gt). Raw steel production in China, the leading world producer of raw steel, increased by 9.3% to about 627 Mt. MEPS (International) Ltd. (2011) forecast that world raw steel production would increase by 5% to 1.49 Gt in 2011 from that in 2010, and by 4.4% in 2012.

Manganese metal is used primarily by the aluminum industry followed by the steel industry. The outlook for the aluminum industry is discussed in the Outlook section of the Aluminum chapter of the 2010 USGS Minerals Yearbook, volume I, Metals and Minerals.

EMD is used by the primary and secondary battery industries. As a rough indicator of future EMD consumption, U.S. demand for primary and secondary batteries was projected to increase by

4.8% annually through 2015 to $16.7 billion. Secondary battery sales were forecast to rise faster than those of primary batteries, owing mainly to growth in lead-acid batteries in which EMD is not used, although non-lead-acid secondary batteries were expected to grow faster in percentage terms spurred by increasing usage of high-drain electronic products and increased production of hybrid and electric vehicle batteries such as lithium-ion in which EMD may be used. Sales of secondary batteries were expected to increase at an annual rate of 5.7% through 2015. The value of global primary and secondary battery consumption was forecast to increase by 4.8% annually through 2014 to $109 billion, with U.S consumption expanding below the average global rate (Freedonia Group, Inc., The, 2010, 2011).

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TABLE 1
SALIENT MANGANESE STATISTICS[1]

(Thousand metric tons, gross weight, unless otherwise specified)

		2006	2007	2008	2009	2010
United States:						
Manganese ore (20% or more Mn):						
Exports		2	29	48	15	14
Imports for consumption		572	602	571	269	489
Consumption[2]		365	351	464	422	468
Stocks, December 31, consumers[2]		153	190	255	115	89
Ferromanganese:						
Exports		22	29	23	24	19
Imports for consumption		358	315	448	153	326
Consumption		297	272	304	242	292
Stocks, December 31, consumers and producers		31	31	27	31	30
Consumption, apparent, manganese content[3]		1,060	979	844	451 r	758
Price, average:						
Ferromanganese, high-carbon[4]	dollars per gross ton	867.51	1,420.00	2,740.00	1,210.00	1,400.00
Ferromanganese, medium-carbon[4]	cents per pound	66.83	104.98	213.13	100.52	129.09
Manganese metal[5]	do.	75.52	199.39	197.64	140.13	162.60
Manganese ore price, c.i.f.[6]	dollars per metric ton unit	3.22	3.10	12.15	7.95 r	9.18
Silicomanganese[4]	cents per pound	39.57	76.72	100.87	50.72	64.27
World, production of manganese ore		33,100 r	35,100	38,300 r	33,800 r	42,700

[r] Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits.

[2] Exclusive of iron and steel plants.

[3] Based on estimates of average content for all significant components except imports, for which content is reported.

[4] Platts Metals Week, dealer import prices based on monthly averages.

[5] Ryan's Notes North American transaction prices based on weekly averages.

[6] Cost, insurance, and freight, U.S. ports.

TABLE 2
U.S. GOVERNMENT DISPOSAL AUTHORITIES AND INVENTORIES FOR MANGANESE MATERIALS AS OF YEAREND 2010[1]

(Metric tons, gross weight)

		Physical inventory[e]				
		Uncommitted				
Material	Disposal authority	Stockpile grade	Nonstockpile grade	Total	Sold, pending shipment	Grand total
Metallurgical ore[2]	(8,910)	--	(8,910)	(8,910)	XX	(8,910)
High-carbon ferromanganese	398,000	368,000	--	368,000	29,700	398,000

[e] Estimated. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Negative inventory, as reported by the Defense Logistics Agency, DLA Strategic Materials.

Source: Defense Logistics Agency, DLA Strategic Materials.

TABLE 3
DOMESTIC PRODUCERS OF MANGANESE PRODUCTS IN 2010

Company	Plant location	Products[1]			Type of process
		FeMn	SiMn	MnO_2	
Energizer Holdings, Inc., Eveready Battery Co.	Marietta, OH			X	Electrolytic.
Erachem Comilog, Inc.	Baltimore, MD			X	Chemical.
Do.	New Johnsonville, TN			X	Electrolytic.
Eramet Marietta, Inc.	Marietta, OH	X	X		Electric furnace.
Felman Productions Inc.	Letart, WV		X		Do.
Tronox Inc.	Henderson, NV			X	Electrolytic.

Do. Ditto.

[1] FeMn, ferromanganese; SiMn, silicomanganese; MnO_2, synthetic manganese dioxide.

TABLE 4
U.S. CONSUMPTION, BY END USE, AND INDUSTRY STOCKS OF MANGANESE FERROALLOYS AND METAL IN 2010[1]

(Metric tons, gross weight)

End use	Ferromanganese			Silicomanganese	Manganese metal
	High carbon	Medium and low carbon	Total		
Steel:					
Carbon	111,000	107,000	218,000	56,300	1,560
High-strength, low-alloy	18,800	10,600	29,300	5,850	--
Stainless and heat-resisting	6,630	2,160	8,790	14,200	968
Full alloy	13,900	14,000	27,800	16,700	1
Unspecified[2]	670	380	1,050	904	1,650
Total	151,000	134,000	285,000	93,900	4,170
Cast irons	6,640	331	6,970	460	5
Superalloys	W	W	W	--	316
Alloys (excluding alloy steels)	454	251	705	2,920	11,400
Miscellaneous and unspecified	W	W	W	W	W
Grand total	158,000	134,000	292,000	97,300[3]	15,800
Total manganese content[4]	123,000	108,000	231,000	64,200	15,800
Stocks, December 31, 2010, consumers and producers	7,590	9,820	30,000	28,000	608

W Withheld to avoid disclosing company proprietary data; included with "Alloys (excluding alloy steels)." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes electrical and tool steel.

[3] Internal evaluation indicates that silicomanganese consumption is considerably understated.

[4] Estimated based on typical percentages of manganese content.

TABLE 5

U.S. EXPORTS OF MANGANESE ORE, FERROALLOYS, METAL AND MANGANESE DIOXIDE, BY COUNTRY[1]

	2009		2010	
Country	Quantity, gross weight (metric tons)	Value, f.a.s.[2] (thousands)	Quantity, gross weight (metric tons)	Value, f.a.s.[2] (thousands)
Ore and concentrates with 20% or more manganese:[3]				
Canada	13,900	$923	3,160	$366
China	--	--	8,790	2,190
Germany	668	1,750	75	278
Korea, Republic of	527	893	306	395
Other (20 countries)	184	256	1,620	2,760
Total	15,300	3,830	13,900	5,990
Ferromanganese, all grades:[4]				
Brazil	480	626	2,170	3,750
Canada	10,900	11,600	5,550	8,130
Chile	540	488	1,570	2,720
Japan	1,000	1,400	--	--
Malaysia	1,080	1,160	8	22
Mexico	6,890	8,220	9,610	12,700
Netherlands	2,260	2,620	--	--
Other (16 countries)	969	1,770	210	472
Total	24,200	27,900	19,100	27,800
Silicomanganese:[4]				
Canada	5,410	5,580	2,150	4,590
Italy	2,540	2,010	--	--
Mexico	7,050	6,510	5,030	6,760
Netherlands	1,490	1,340	--	--
Other (12 countries)	2,290	2,040	2,180	1,720
Total	18,800	17,500	9,360	13,100
Metal, including alloys and waste and scrap:[3]				
China	894 [r]	2,200 [r]	690	1,640
Hong Kong	820	2,340	849	3,530
India	205	452	626	1,450
Japan	462	1,010	311	683
Other (23 countries)	772	2,090	1,190	3,020
Total	3,150 [r]	8,090 [r]	3,660	10,300
Manganese dioxide:[4]				
Belgium	1,930	4,870	1,790	4,220
Canada	4,090	3,900	4,090	4,220
Other (48 countries)	2,400	4,650	3,100	6,220
Total	8,420	13,400	8,990	14,700

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship.

[3] Countries listed imported more than 300 metric tons from the United States based on a 2-year average.

[4] Countries listed imported more than 500 metric tons from the United States based on a 2-year average.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF MANGANESE ORE, FERROALLOYS, METAL, AND SELECTED CHEMICALS, BY COUNTRY[1]

	2009			2010		
	Quantity		Value,	Quantity		Value,
Country	Gross weight (metric tons)	Mn content (metric tons)	customs (thousands)	Gross weight (metric tons)	Mn content (metric tons)	customs (thousands)
Ore and concentrates with 20% or more manganese:[2]						
All grades:						
Australia	35,700	15,400	$12,300	86,400	65,200	$24,900
Belgium	1,180	609	136	--	--	--
Brazil	2,960	1,540	930	6,780	3,440	2,520
China	4,170	2,150	618	707	481	637
Gabon	186,000	96,500	65,000	246,000	125,000	70,700
Georgia	--	--	--	12,400	8,610	13,000
Ghana	37,500	37,100	3,400	36,600	10,300	5,080
Mexico	1,490	671	304	2,920	1,050	687
Morocco	16	9	12	1,540	791	217
South Africa	--	--	--	95,400	40,100	15,500
Total	269,000	154,000	82,600	489,000	255,000	133,000
More than 20% but less than 47% manganese:[2]						
Australia	25,600	10,500	10,200	--	--	--
Gabon	--	--	--	16,800	7,480	2,320
Ghana	--	--	--	36,600	10,300	5,080
Mexico	1,490	671	304	2,920	1,050	687
South Africa	--	--	--	77,400	30,300	9,490
Total	27,100	11,100	10,500	134,000	49,100	17,600
47% or more manganese:[2]						
Australia	10,100	4,970	2,070	86,400	65,200	24,900
Belgium	1,180	609	136	--	--	--
Brazil	2,960	1,540	930	6,780	3,440	2,520
China	4,170	2,150	618	707	481	637
Gabon	186,000	96,500	65,000	229,000	117,000	68,300
Georgia	--	--	--	12,400	8,610	13,000
Ghana	37,500	37,100	3,400	--	--	--
Morocco	16	9	12	1,540	791	217
South Africa	--	--	--	18,000	9,850	6,010
Total	242,000	143,000	72,100	355,000	206,000	116,000
Ferromanganese:						
All grades:[3]						
Australia	11,000	8,460	11,600	4,040	3,140	4,200
China	10,100	9,160	24,600	32,900	28,000	75,500
France	--	--	--	15,700	11,200	19,000
Korea, Republic of	8,790	7,120	15,700	16,900	13,500	35,700
Mexico	7,750	6,110	13,300	21,500	17,200	44,000
Norway	10,100	8,250	16,300	35,000	28,000	56,600
South Africa	90,200	69,900	118,000	152,000	118,000	199,000
Ukraine	4,290	3,360	3,670	40,300	31,600	47,100
Other (14 countries)	10,800 r	8,340 r	11,600 r	8,310	6,350	11,900
Total	153,000	121,000	215,000	326,000	257,000	493,000
1% or less carbon:						
China	8,580	7,940	21,900	21,700	19,000	55,100
Korea, Republic of	3,460	2,810	5,370	--	--	--
Mexico	4,340	3,450	8,090	10,200	8,200	21,100
Norway	2,660	2,160	4,720	3,810	3,090	7,830
South Africa	1,020	827	2,560	23	21	70
Other (4 countries)	27	21	58	3,800	3,140	8,740
Total	20,100	17,200	42,700	39,500	33,500	92,800
More than 1% to 2% or less carbon:						
China	740	600	1,610	11,100	8,890	20,300

See footnotes at end of table.

TABLE 6—Continued

U.S. IMPORTS FOR CONSUMPTION OF MANGANESE ORE, FERROALLOYS, METAL, AND SELECTED CHEMICALS, BY COUNTRY[1]

	2009			2010		
	Quantity			Quantity		
Country	Gross weight (metric tons)	Mn content (metric tons)	Value, customs (thousands)	Gross weight (metric tons)	Mn content (metric tons)	Value, customs (thousands)
More than 1% to 2% or less carbon—Continued:						
Korea, Republic of	4,630	3,770	$9,460	12,400	9,920	$27,100
Mexico	1,520	1,210	3,080	11,300	8,970	22,900
Norway	7,410	6,030	11,400	18,500	14,900	34,600
South Africa	12,300	9,740	26,800	31,200	24,700	55,000
Other (6 countries)	39	31	198	1,270	1,010	2,650
Total	26,600	21,400	52,600	85,900	68,400	163,000
More than 2% but not more than 4% carbon:						
China	--	--	--	60	32	114
Norway	16	13	25	--	--	--
South Africa	216	179	500	180	166	464
Other (2 countries)	405	304	460	51	40	51
Total	637	496	986	291	238	629
More than 4% carbon:						
Australia	11,000	8,460	11,600	4,040	3,140	4,200
China	816	614	1,140	--	--	--
France	--	--	--	15,700	11,200	19,000
Korea, Republic of	701	546	870	1,500	1,130	1,800
Mexico	1,900	1,450	2,130	8	6	15
Norway	57	46	92	12,700	9,980	14,200
South Africa	76,700	59,100	88,600	120,000	93,100	144,000
Ukraine	4,290	3,360	3,670	40,300	31,600	47,100
Other (9 countries)	10,400 r	7,990 r	11,000 r	6,190	4,580	7,260
Total	106,000	81,600	119,000	201,000	155,000	237,000
Silicomanganese:[3]						
Australia	18,400	12,200	17,200	31,200	20,700	32,700
Georgia	20,300	13,500	15,600	79,200	54,300	98,100
Korea, Republic of	7,090	4,620	6,380	--	--	--
Mexico	1,600	1,050	1,660	12,500	8,180	14,700
Norway	15,200	9,460	22,300	38,300	23,900	61,600
Saudi Arabia	8,760	3,510	7,540	2,540	1,670	2,990
South Africa	55,400	36,800	60,500	122,000	81,500	145,000
Other (9 countries)	3,600	2,320	4,040	10,700	6,710	17,700
Total	130,000	83,500	135,000	297,000	197,000	373,000
Metal:[2]						
Unwrought:[4]						
China	15,500	XX	38,100	25,900	XX	64,400
Germany	555	XX	1,660	852	XX	2,650
South Africa	4,980	XX	14,100	5,450	XX	18,300
Other (10 countries)	459	XX	1,150	2,450	XX	6,490
Total	21,500	XX	55,000	34,600	XX	91,800
Other manganese, wrought:						
Mexico	299	XX	1,530	477	XX	2,630
Other (9 countries)	315	XX	918	140	XX	482
Total	614	XX	2,450	617	XX	3,110
Waste and scrap:						
Canada	701	XX	239	698	XX	300
Other (5 countries)	185	XX	131	88	XX	138
Total	886	XX	370	786	XX	438

See footnotes at end of table.

TABLE 6—Continued

U.S. IMPORTS FOR CONSUMPTION OF MANGANESE ORE, FERROALLOYS, METAL, AND SELECTED CHEMICALS, BY COUNTRY[1]

	2009			2010		
	Quantity		Value, customs (thousands)	Quantity		Value, customs (thousands)
Country	Gross weight (metric tons)	Mn content (metric tons)		Gross weight (metric tons)	Mn content (metric tons)	
Manganese dioxide:[2]						
Japan	4,570	XX	$11,400	7,220	XX	$16,000
South Africa	12,200	XX	29,200	13,100	XX	36,400
Other (14 countries)	733	XX	1,310	1,620	XX	2,720
Total	17,500	XX	42,000	21,900	XX	55,100
Potassium permanganate:[2]						
Czech Republic	565	XX	1,870	385	XX	1,150
India	560	XX	1,870	690	XX	2,140
Other (2 countries)	18	XX	62	14	XX	51
Total	1,140	XX	3,800	1,090	XX	3,330

[r]Revised. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Countries listed exported more than 300 metric tons (gross weight) to the United States based on the 2-year average.

[3] Countries listed exported more than 5,000 metric tons (gross weight) of total manganese alloys to the United States based on the 2-year average.

[4] Imports of unwrought metal include flake, powder, and other.

Source: U.S. Census Bureau, data adjusted by the U.S. Geological Survey.

TABLE 7

MANGANESE MATERIALS: FINAL ANTIDUMPING DUTY RATES ASSESSED IN 2010, BY DATE[1]

Date	Imported material	Country of origin	Period of investigation	Producer and duty rate
August 26	Potassium permanganate	China	5-year review[2]	All imports (128.94%).

[1] Antindumping duties are assessed by the U.S. International Trade Commission (ITC).

[2] Conducted on existing antidumping duty order by the International Trade Administration of the U.S. Department of Commerce.

Source: Federal Register.

TABLE 8
MANGANESE ORE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	Mn content, percentage[e, 4]	2006	2007	2008	2009	2010
Australia:[5]						
Gross weight		4,556	5,289	4,812	4,451	6,465
Mn content[e]	37–53	2,192 [6]	2,540	2,320	2,140	3,100
Brazil:[7]						
Gross weight		3,390	1,570	3,160	2,350 [r]	2,400 [p]
Mn content	33–51	1,120	520	1,040	778 [r]	780 [p]
China:[e, 8, 9]						
Gross weight		8,000	10,000	11,000	12,000	13,000
Mn content	20–30	1,600	2,000	2,200	2,400	2,600
Gabon:[10]						
Gross weight		3,000	3,300	3,250	1,992 [r]	3,201
Mn content	45–53	1,393	1,532	1,441	881	1,416
Ghana:						
Gross weight		1,659	1,173	1,261	1,007	1,000 [e]
Mn content[e]	32–34	580	410	440	351	350
India:[11]						
Gross weight		2,084	2,300 [e]	2,400	2,500	2,600
Mn content	10–54	844	900 [e]	960	980	1,000
Kazakhstan, crude ore:						
Gross weight		2,531	2,482	2,485	2,457 [r]	3,042
Mn content[e]	20–30	550	600	600	520 [r]	640
Mexico:[12]						
Gross weight		346	423	472 [e]	330 [r, e]	485 [e]
Mn content	36–37	124	152	170	119 [r]	175
South Africa:[10]						
Gross weight		5,213	5,996	6,807	4,576	7,172
Mn content	30–48+	2,300	2,600	2,900	1,900 [e]	2,900
Ukraine:						
Gross weight		1,606	1,720	1,447	932	1,589
Mn content[e]	30–35	546	580	492 [r]	316 [r]	540
Other:[e, 13]						
Gross weight		752 [r]	865 [r]	1,220 [r]	1,180 [r]	1,720
Mn content	XX	228 [r]	275 [r]	434 [r]	411 [r]	672
Total:						
Gross weight		33,100 [r]	35,100	38,300 [r]	33,800 [r]	42,700
Mn content	XX	11,500	12,100	13,000 [r]	10,800	14,200

[e] Estimated. [p] Preliminary. [r] Revised. XX Not applicable.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through January 2, 2012. Data pertain to concentrates or comparable shipping product, except that in a few instances the best data available appear to be for crude ore, possibly after some upgrading.

[3] In addition to the countries listed, Cuba, Panama, and Philippines may have produced manganese ore and (or) manganiferous ore, but available information is inadequate to make reliable estimates of output levels.

[4] May be average content of each year's production rather than for content of typical products.

[5] Metallurgical ore.

[6] Reported figure.

[7] Production of beneficiated ore as reported in Mineral Summary, Brasilia, Brazil. Average content 43% Mn. Contains imports from China and South Africa.

[8] Includes manganiferous ore.

TABLE 8—Continued

MANGANESE ORE: WORLD PRODUCTION, BY COUNTRY[1, 2]

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[9] The International Manganese Institute estimated Chinese manganese ore production, in gross weight and Mn content, respectively, to be in metric tons, as follows: 2006—11,000,000 and 2,200,000; 2007—14,000,000 and 2,800,000; 2008—19,000,000 and 3,400,000; 2009—15,000,000 and 2,700,000; and 2010—17,000,000 and 3,100,000.

[10] Calculated metal content includes allowance for assumed moisture content. Includes ore and sinter.

[11] Reported on a fiscal year-basis. Much of India's production grades below 35% Mn; content averaged 38.3% Mn for fiscal years 2006–07 through 2010–11.

[12] Mostly oxide nodules; may include smaller quantities of direct-shipping carbonate and oxide ores for metallurgical and battery operations.

[13] Category represents the combined totals of Bosnia and Herzegovina, Bulgaria, Burkina Faso, Burma, Chile, Colombia, Cote d'Ivoire, Egypt, Georgia, Hungary, Indonesia, Iran, Italy (from wastes), Morocco, Namibia, Romania, Russia (crude ore), Sudan, Thailand, Turkey, and Zambia.

TABLE 9

FERROMANGANESE AND SILICOMANGANESE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2006	2007	2008	2009[e]	2010[e]
Argentina, electric furnace, silicomanganese	9,268	8,917	9,172	6,644 [3]	6,000
Australia, electric furnace:[e]					
Ferromanganese	125,000	115,000	147,000	87,000	136,000
Silicomanganese	120,000	110,000	125,000	74,000	131,000
Total	245,000	225,000	272,000	161,000	267,000
Brazil, electric furnace:					
Ferromanganese	280,770	205,000 [r]	190,000 [r]	75,000 [r]	103,000 [p, 3]
Silicomanganese[e]	292,230 [3]	214,000	198,000	79,000 [r]	107,000
Total	573,000	419,000 [r]	388,000 [r]	154,000 [r]	210,000 [3]
China:[e]					
Blast furnace, ferromanganese	600,000	600,000	600,000	350,000 [r]	350,000
Electric furnace:					
Ferromanganese	1,400,000	1,930,000	2,100,000	2,070,000 [r]	2,300,000
Silicomanganese	3,600,000	4,340,000	5,000,000	5,430,000 [r]	5,700,000
Total	5,000,000	6,270,000	7,100,000	7,500,000 [r]	8,000,000
Total, blast and electric furnaces	5,600,000	6,870,000	7,700,000	7,850,000 [r]	8,350,000
Egypt, electric furnace, ferromanganese[e]	30,000	30,000	30,000	30,000	30,000
France, electric furnace:[e]					
Ferromanganese	137,000	144,000	46,600	46,000	138,000
Silicomanganese[4]	63,300	65,400	60,200	54,100	54,000
Total	200,000	209,000	107,000	100,000	192,000
Georgia, electric furnace:[e]					
Ferromanganese	5,130 [3]	5,000	5,000	NA [r, 3]	NA [3]
Silicomanganese	116,945 [3]	120,000	120,000	112,016 [r, 3]	203,464 [3]
Total	122,075 [3]	125,000	125,000	112,016 [r, 3]	203,464 [3]
India, electric furnace:[5]					
Ferromanganese	296,726	391,210	384,577	389,465 [3]	390,000
Silicomanganese	782,962	911,402	891,458	1,099,838 [3]	1,000,000
Total	1,079,688	1,302,612	1,276,035	1,489,303 [3]	1,390,000
Indonesia, electric furnace:[e]					
Ferromanganese	12,000	12,000	12,000	12,000	12,000
Silicomanganese	5,000	6,000	7,000	7,000	8,000
Total	17,000	18,000	19,000	19,000	20,000
Iran, electric furnace, ferromanganese	-- [r]	-- [r]	-- [r]	-- [r, 3]	-- [3]
Italy, electric furnace:[e]					
Ferromanganese	4,500	4,800	8,500	5,500	17,000
Silicomanganese	33,500	37,000	25,500	17,000	23,000
Total	38,000	41,800	34,000	22,500	40,000
Japan, electric furnace:					
Ferromanganese	406,162	420,151	431,181	361,375 [3]	453,265 [3]
Silicomanganese	59,424	52,901	58,884	49,205 [3]	49,865 [3]
Total	465,586	473,052	490,065	410,580 [3]	503,130 [3]
Kazakhstan, electric furnace:					
Ferromanganese[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Silicomanganese	218,323 [r]	188,445	179,939	200,374 [r, 3]	215,000 [3]
Total	218,323 [r]	188,445 [r]	179,939 [r]	200,374 [r, 3]	215,000 [3]

See footnotes at end of table.

TABLE 9—Continued
FERROMANGANESE AND SILICOMANGANESE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2006	2007	2008	2009[e]	2010[e]
Korea, Republic of, electric furnace:					
Ferromanganese	169,202	209,321	251,125	250,000[r]	250,000
Silicomanganese	94,119	105,607	76,184	80,000[r]	80,000
Total	263,321	314,928	327,309	330,000[r]	330,000
Macedonia, electric furnace:					
Ferromanganese	--	--	12,623	--[3]	--[3]
Silicomanganese	--	70,472	54,931	--[3]	--[3]
Total	--	70,472	67,554	--[3]	--[3]
Mexico, electric furnace:[6]					
Ferromanganese	62,485	74,578	97,366	42,492[3]	42,000
Silicomanganese	97,457	109,286	114,320	85,065[3]	85,000
Total	159,942	183,864	211,686	127,557[3]	127,000
Norway, electric furnace:[e]					
Ferromanganese	245,000	245,000	309,000	205,000	297,000
Silicomanganese	230,000	225,000	252,000	200,000	249,000
Total	475,000	470,000	561,000	405,000	546,000
Poland:					
Blast furnace, ferromanganese	4,100	2,100	8,500[r]	1,700[r]	2,000
Electric furnace, silicomanganese	3,310	15,600	25,100[r]	14,000[r]	15,000
Total	7,410	17,700	33,600[r]	15,700[r]	17,000
Romania, electric furnace:					
Ferromanganese	3,329	--	--	--	--
Silicomanganese	53,085	26,868	10,000	--	20,000[3]
Total	56,414	26,868	10,000	--	20,000[3]
Russia:[e]					
Blast furnace, ferromanganese	130,000	120,000	110,000	88,000[r, 3]	171,600[3]
Electric furnace, silicomanganese	40,000	40,000	40,000	98,700[r, 3]	147,900[3]
Total	170,000	160,000	150,000	186,700[r, 3]	319,500[3]
Slovakia, electric furnace:					
Ferromanganese	59,391	74,065	61,194	21,000[r]	25,000
Silicomanganese	59,128	71,587	59,940	32,000[r]	35,000
Total	118,519	145,652	121,134	53,000[r]	60,000
South Africa, electric furnace:					
Ferromanganese	656,235	698,654	503,000	260,000	530,000[3]
Silicomanganese[e]	247,000	302,000	233,000	110,000	230,000
Total	903,235	1,000,654	736,000	370,000	760,000[3]
Spain, electric furnace:[e]					
Ferromanganese	148,000[r]	155,000[r]	163,000[r]	68,000[r]	152,000
Silicomanganese	145,000[r]	153,000[r]	160,000[r]	67,000[r]	150,000
Total	293,000[r]	308,000[r]	323,000[r]	135,000[r]	302,000
Ukraine:					
Blast furnace, ferromanganese	30,000	26,700	16,000	--	--[3]
Electric furnace:					
Ferromanganese	373,000	368,000	362,400[r]	129,400[3]	280,100[3]
Silicomanganese	1,168,000	1,281,000	894,900[r]	741,900[3]	940,400[3]
Total	1,541,000	1,649,000	1,257,300[r]	871,300[3]	1,220,500[3]
Total, blast and electric furnaces	1,571,000	1,675,700	1,273,300[r]	871,300[3]	1,220,500[3]
United States, electric furnace, ferromanganese[7]	W	W	W	W[3]	W[3]

See footnotes at end of table.

TABLE 9—Continued

FERROMANGANESE AND SILICOMANGANESE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country	2006	2007	2008	2009[e]	2010[e]
Venezuela, electric furnace:[e]					
Ferromanganese	15,000	15,000	15,000	15,000	15,000
Silicomanganese	35,000	35,000	35,000	35,000	35,000
Total	50,000	50,000	50,000	50,000	50,000
Grand total	12,700,000 r	14,300,000 r	14,500,000 r	13,100,000	15,200,000
Of which:					
Blast furnace, ferromanganese	764,000	749,000	735,000 r	440,000 r	524,000
Electric furnace, excluding United States:					
Ferromanganese	4,430,000 r	5,100,000 r	5,130,000 r	4,070,000 r	5,170,000
Silicomanganese[8]	7,470,000 r	8,490,000 r	8,630,000 r	8,590,000 r	9,480,000
Total	11,900,000 r	13,600,000 r	13,800,000 r	12,700,000 r	14,700,000

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; not included in "Grand total." – Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through January 31, 2012.

[3] Reported figure.

[4] Includes silicospiegeleisen, if any.

[5] Reported on a fiscal year basis, which is from April 1 to March 31.

[6] Salable products from Cía Minera Autlán S.A. de C.V.

[7] U.S. output of ferromanganese includes silicomanganese.

[8] Includes silicospiegeleisen, if any, for France.

TABLE 10

MANGANESE MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY YEAREND 2014[1, 2, 3]

(Metric tons, gross weight, unless otherwise specified)

Projected year of first production	Country (state/province)	Project and company	Project type	Incremental annual production capacity	Total annual production capacity	Manganese product[4]
2010	Australia (East Pilbara)	Nicholas Downs (formerly Balfour Downs) Manganese Mine Mineral Resources Ltd. (50%) and Hancock Prospecting Pty. Ltd. (50%)	mine expansion	NA	350,000	Mn ore.
2010	Australia (Western)	Peak Hill District Manganese Mine Mineral Resources Ltd.	do.	85,000	220,000	Do.
2010	Burkina Faso (Tuy)	Kiere Manganese Mine Burkina Manganese S.A.	new mine	NA	50,000	Do.
2010	China (Chongzuo, Guangxi)	China International Trust and Investment Corporation (CITIC) Dameng Tiandong Plant China International Trust and Investment Corporation (CITIC) Dameng Tiandong New Materials Co., Ltd.	new EMM plant	NA	30,000	EMM.
2010	China (Henan)	Wuhai Mengjin Smelting Wuhai Mengjin Smelting Co. Ltd.	ferroalloys plant expansion	120,000	170,000	SiMn.

See footnotes at end of table.

TABLE 10—Continued
MANGANESE MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY YEAREND 2014[1, 2, 3]

(Metric tons, gross weight, unless otherwise specified)

Projected year of first production	Country (state/province)	Project and company	Project type	Incremental annual production capacity	Total annual production capacity	Manganese product[4]
2010	India (Haldia, West Bengal)	Rohit Ferro Tech Haldia Plant Rohit Ferro Tech Ltd.	ferroalloys plant expansion	NA	67,000 [r]	FeMn, SiMn.
2010[e]	Namibia (Okahandja)	Otjosondu Manganese Mine Purity Manganese (pty) Ltd.	mine expansion	480,000	600,000	Mn ore.
2010	South Africa (Mpumalanga)	Machadodorp Ferroalloys Plant[5] Assmang Ltd.	ferroalloys plant conversion	NA	75,000	HC FeMn.
2010	South Africa (Northern Cape)	Kalahari Manganese Mine United Manganese of Kalahari	mine expansion	1,250,000 [r]	1,500,000 [r]	Mn ore.
2010	Zambia (Central and Mansa)	Kabasa, Kabulu, Kansambo Mines[6] Genesis Procurement Company and Luapula Base Metals Ltd.	do.	NA	48,000	Do.
2011	Australia (Northern)	Bootu Creek Manganese Mine OM Holdings Ltd.	do.	150,000	1,000,000	Do.
2011	Australia (Western)	Peak Hill District Manganese Mine Mineral Resources Limited	do.	60,000	280,000	Do.
2011	China (Chongzuo, Guangxi)	Eramet New Guilin Ferroalloys Plant Eramet S.A.	new ferroalloys plant	NA	105,000 [r] 60,000	HC FeMn, SiMn. MC FeMn, LC FeMn.
2011	Do.	Pingle (formerly Guangxi) EMM Plant Guangxi Zhaohong Manganese Industry Co., Ltd.	new EMM plant	NA	24,000	EMM.
2011	Côte d'Ivoire (Grand-Lahou)	Lauzoua Mine Compagnie Minière du Littoral (CML)	new mine	NA	300,000 [r]	Mn ore.
2011[r]	Gabon (Moyen-Ogooué)	M'Bembélé Manganese Mine Compagnie Industrielle et Commerciale des Mines de Huazhou (CICMH)	do.	NA	1,150,000 [r]	Do.
2011	India (Sundargarh, Orissa)	Patmunda Manganese Mine[7] Orissa Manganese and Minerals Pvt. Ltd.	mine expansion	210,000	360,000	Do.
2011	Do.	Siljora Kalimati Manganese & Iron Ore Mine Rungta Mines Ltd.	do.	129,000 [e]	189,000 [e]	Do.
2011	India	10 mines MOIL Ltd.[8]	do.	360,000 [r]	1,200,000 [r]	Do.
2011	Korea, Republic of (Gangwon)	Donghae Ferroalloys Plant Dongbu Metal Co., Ltd.	ferroalloys plant expansion	270,000	500,000	HC FeMn, MC FeMn, LC FeMn, SiMn.
2011	Korea, Republic of (South Jeolla)	Gwangyang FeMn Plant POS-HiMetal	new ferroalloys plant	NA	75,000	MC FeMn, LC FeMn.
2011	Mexico (Hidalgo)	Tajo Naopa Manganese Mine Minera Autlán Sociedad Anónima Bursátil de Capital Variable (SAB de CV)	new mine	NA	300,000 [e]	Mn ore.
2011	Russia (Mezhdure-chensk, Kemerovo)	Usink Manganese Mine Filial Zakrytogo Aktsionernogo Obshchestiva (ZAO) CHEK-SU.VK V	do.	NA	300,000 [e]	Do.

See footnotes at end of table.

TABLE 10—Continued

MANGANESE MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY YEAREND 2014[1,2,3]

(Metric tons, gross weight, unless otherwise specified)

Projected year of first production	Country (state/province)	Project and company	Project type	Incremental annual production capacity	Total annual production capacity	Manganese product[4]
2011	South Africa (Northern Cape)	Kalahari Manganese Mine United Manganese of Kalahari	mine expansion	600,000	2,100,000	Do.
2011[e]	South Africa (North West)	Kudumane Manganese Mine Asia Minerals Ltd. (AML)	new mine	NA	500,000 [e]	Do.
2012	Australia (East Pilbara)	Nicholas Downs (formerly Balfour Downs) Manganese Mine Mineral Resources Ltd. (50%) and Hancock Prospecting Pty. Ltd. (50%)	mine expansion	370,000	720,000	Do.
2012[e]	Côte d'Ivoire (Grand-Lahou)	Lauzoua Mine Compagnie Minière du Littoral (CML)	do.	200,000	500,000	Do.
2012	China (Hunan)	Kingray Changsha EMM Plant Kingray New Materials Science & Technology Co., Ltd.	EMM plant expansion	30,000	40,000	EMM.
2012[e]	China (Jilin)	Sinosteel Jilin Ferroalloys Plant Sinosteel Jilin Ferroalloy Co., Ltd.	new ferroalloys plant	NA	100,000	MC FeMn, LC FeMn.
2012	Gabon (Haut-Ogooué)	Moanda Mine Compagnie Miniere de l'Ogooue (Comilog) S.A.	mine expansion	300,000	4,000,000	Mn ore.
2012[r]	India (Burdwan, West Bengal)	Maithan Vizag Ferro-Alloys Plant Maithan Alloys Limited	new ferroalloys plant	NA	120,000	Mn alloys.
2012	India (Andhra Pradesh)	Sarda Vizag Ferroalloys Plant Sarda Energy & Minerals Ltd.	do.	NA	100,000	FeMn, SiMn.
2012	Mali (Gao)	Ansongo Manganese Mine Mali Manganese S.A.	new mine	NA	280,000	Mn ore.
2012	Russia (Siberia)	Siberian Mining and Metallurgical Company (SGMK) Manganese Mine[9] Siberian Mining and Metallurgical Company (SGMK)	do.	NA	600,000	Do.
2012	South Africa (Mpumalanga)	Machadodorp Ferroalloys Plant[5] Assmang Ltd.	ferroalloys plant conversion	100,000	175,000	HC FeMn.
2012	South Africa (Northern Cape)	Kalagadi Manganese Mine[10] Kalagadi Manganese (50%) and ArcelorMittal (50%)	new mine-beneficiation-sinter complex	NA	3,000,000	Mn ore.
2012	Do.	Kalahari Manganese Mine United Manganese of Kalahari	mine expansion	600,000	2,700,000	Do.
2012	Do.	Tshipi Kalahari Manganese Mine Jupiter Mines Ltd. (49.9%) and Ntsimbintle Mining (Pty) Ltd. (50.1%)	new mine	NA	200,000	Mn ore.
2012	Do.	Wessels Mine BHP Billiton Ltd. (44.4%), Anglo American Corp. (29.6%), Ntsimbintle (9%), and others (17%)	mine expansion	500,000	1,500,000	Do.
2012	Zambia (Luapula)	Taurian Manganese Ltd. Mines[11] Dharni Sampda Private Ltd. Group (formerly Taurian Resources Private Ltd.)	new mine	NA	240,000	Do.

See footnotes at end of table.

TABLE 10—Continued
MANGANESE MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY YEAREND 2014[1, 2, 3]

(Metric tons, gross weight, unless otherwise specified)

Projected year of first production	Country (state/province)	Project and company	Project type	Incremental annual production capacity	Total annual production capacity	Manganese product[4]
2013	Australia (Northern Territory, Western Australia)	Groote Eylandt Mining Company Pty. Ltd. BHP Billiton Ltd. (60%) and Anglo American Corp. (40%)	mine expansion	600,000	4,800,000	Do.
2013[e]	China (Chongzuo, Guangxi)	Pingle (formerly Guangxi) EMM Plant Guangxi Zhaohong Manganese Industry Co., Ltd.	EMM plant expansion	36,000	60,000	EMM.
2013[e]	China (Jilin)	Sinosteel Jilin Ferroalloys Plant Sinosteel Jilin Ferroalloy Co., Ltd.	ferroalloys plant expansion	600,000 [e]	1,000,000	FeMn.
2013	Gabon (Haut-Ogooué)	Moanda Metallurgical Complex Compagnie Miniere de l'Ogooue (Comilog) S.A.	new EMM and ferroalloys plants	NA NA	65,000 20,000	SiMn. EMM.
2013[r]	India (Bhandara, Maharashtra)	Chandrapur Plant[12] Maharashtra Elektrosmelt Ltd.	ferroalloys plant expansion	90,000 [e]	190,000 [e]	FeMn, SiMn.
2013	Kazakhstan (Aktobe)	Aktobe Ferroalloys Plant Eurasian Natural Resources Corp. plc	new ferroalloys plant	NA	400,000	HC FeMn.
2013	Kazakhstan (Almaty)	Tekeli EMM Plant Electro Manganese and ThyssenKrupp AG	new EMM plant	NA	30,000	EMM.
2013	Malaysia (Johor Bahru)	Tanjung Langsat Project OM Materials (Johor) Sdn Bhd	new ferroalloys and sintering plants	NA NA	300,000 66,000	Mn ore. HC FeMn.
2013	Malaysia (Sarawak)	Samalaju Ferroalloys Plant[13] Asia Minerals Ltd (AML)	new ferroalloys plant	NA	132,000	MC FeMn, LC FeMn, SiMn.
2013	Mali (Gao)	Ansongo Manganese Mine Mali Manganese S.A.	mine expansion	270,000	550,000	Mn ore.
2013[r]	South Africa (Eastern Cape)	Kalagadi Coega Ferroalloys Plant Kalagadi Manganese (50%) and ArcelorMittal (50%)	do.	NA	320,000	HC FeMn.
2013	South Africa (Northern Cape)	Tshipi Kalahari Manganese Mine Jupiter Mines Ltd. (49.9%) and Ntsimbintle Mining (Pty) Ltd. (50.1%)	do.	2,200,000	2,400,000	Mn ore.
2013	South Africa (North West)	Kudumane Manganese Mine Asia Minerals Ltd. (AML)	do.	1,000,000	1,500,000	Do.
2013	Zambia (Central and Luapula)	Various mines[14] Asia Minerals Ltd. (AML)	new mine	NA	250,000	Do.
2014[r]	Cameroon (Haut Nyong, East)	Nkamouna Cobalt-Nickel-Manganese Project Geovic Mining Corporation	new mine	NA	62,800 [r]	Mn ore.
2014	India (Balaghat, Madhya Pradesh; Bhandara, Maharashtra)	Balaghat and Dongri Buzurg Mines MOIL Ltd.[8]	mine expansions	400,000 [e]	1,600,000 [e]	Do.
2014	India (Chhattisgarh)	Bhilai Ferro-Alloys Plant MOIL Ltd.[8] (50%) and Steel Authority of India Ltd. (SAIL) (50%)	new ferroalloys plant	NA NA	75,000 31,000	SiMn. FeMn.

See footnotes at end of table.

TABLE 10—Continued

MANGANESE MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAR, BY YEAREND 2014[1, 2, 3]

(Metric tons, gross weight, unless otherwise specified)

Projected year of first production	Country (state/province)	Project and company	Project type	Incremental annual production capacity	Total annual production capacity	Manganese product[4]
2014[r]	India (Visakhapatnam, Andhra Pradesh)	Bobbili Ferro-Alloys Plant MOIL Ltd.[8] (50%) and Rashtriya Ispat Nigam Ltd. (50%)	new ferroalloys plant	NA NA	37,500 20,000	SiMn. FeMn.
2014	Malaysia (Sarawak)	Samalaju Ferroalloys Plant[13] Asia Minerals Ltd (AML)	ferroalloys plant expansion	108,000	240,000	MC FeMn, LC FeMn, SiMn.
2014	Do.	Sarawak Ferroalloys Plant[15] OM Materials (S) Pte Ltd. (80%) and Cahya Mata Sarawak Berhard (20%)	new ferroalloys plant	NA	300,000	SiMn.
2014[r]	Mali (Gao)	Ansongo Manganese Mine Mali Manganese S.A.	mine expansion	50,000	600,000	Mn ore.
2014	Zambia (Luapula)	Taurian Manganese Ltd. Mines Dharni Sampda Private Ltd. Group (formerly Taurian Resources Private Ltd.)	do.	480,000	720,000	Do.

[e]Estimated. [r]Revised. Do., do. Ditto. NA Not available.

[1] Estimated data are rounded to no more than three significant digits.

[2] Projects in feasibility or later stages of development in 2010–11. Actual startup dates may be postponed, owing to economic or other factors. Additional projects might produce manganese materials by 2014, but not enough information was available to include them.

[3] Includes projects having the following minimum tonnage capacities: 45,000 metric tons per year of manganese alloys or manganese ore; and 10,000 metric tons per year of electrolytic manganese dioxide or electrolytic manganese metal.

[4] EMD Electrolytic manganese dioxide. EMM Electrolytic manganese metal. FeMn Ferromanganese. HC FeMn High-carbon ferromanganese. LC FeMn Low-carbon ferromanganese. MC FeMn Medium-carbon ferromanganese. Mn Manganese. SiMn Silicomanganese.

[5] A total of three ferrochromium furnaces at the Machadodorp Ferroalloys Plant will be converted to high-carbon ferromanganese production by 2012.

[6] These Zambian mines are located in Kabasa (Central Province) and Kabulu and Kansambo (Laupula Province).

[7] Includes five additional manganese mines situated in the region of Sundargarth, Orissa.

[8] Formerly Manganese Ore (India) Ltd. (MOIL). MOIL Ltd. operates 10 mines, 6 of which are located in the Nagpur and Bhandara Districts of Maharashtra and 4 in the Balaghat District of Madhya Pradesh. The company has not specified which mines would be affected by the planned capacity expansion.

[9] The Siberian Mining and Metallurgical Company (SGMK) Manganese Mine will have the capacity to produce 120,000 metric tons per year of manganese concentrates from the total ore mined.

[10] The Kalagadi Manganese sinter plant will have a capacity of 2.4 million metric tons per year.

[11] Taurian Manganese Ltd. Zambian mines are located in Kabwe and Kapiri Mphoshi (Central Province) and Mansa (Luapula Province).

[12] Steel Authority of India Limited (SAIL) became the new owner of the Chandrapur Ferroalloys Plant when it acquired Maharashtra Elektrosmelt Ltd. on on July 12, 2011.

[13] The Samalaju ferroalloys plant will also have the capacity to produce ferrosilicon.

[14] Asia Minerals Ltd. (AML) has Zambian mining and prospecting licenses in the Central Province (Kabwe, Kapiri, Mkushi, Mphoshi, and Serenje) and the Luapula Province (Mansa).

[15] The Sarawak ferroalloys plant will also have a capacity of 300,000 metric tons per year to produce ferrosilicon.

Sources: Company annual reports, presentations, and press releases; unpublished personal communications; and trade publications.

MERCURY

By William E. Brooks

Domestic tables were prepared by Shonta E. Osborne, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, no mines produced mercury as a principal product in the United States. The last mine to produce mercury as its principal product, the McDermitt Mine in northern Nevada, closed in 1992. However, in 2010, mercury was produced as a byproduct of domestic gold-silver processing, mainly in Nevada, and may have been produced as a byproduct of processing other metals. Imported byproduct mercury was processed domestically, and the mercury was resold. Mercury was produced from reclamation of mercury contained in fluorescent lamps and a declining supply of mercury-containing automobile convenience switches, batteries, dental amalgam, electronic waste, medical devices, and thermostats. The chlorine-caustic soda industry was the leading domestic user of mercury for its mercury-cell plants, and some of that mercury was recycled in-plant. Comprehensive data on domestic byproduct and recycled mercury production were not available.

Since 1927, the common unit for measuring and pricing mercury has been the "flask," which was set to conform to the historical measuring system used at Almaden, Spain (Myers, 1951). One flask of mercury weighs 34.5 kilograms (kg), and 1 metric ton (t) of mercury contains approximately 29 flasks. The flask itself is a screw-top, welded-steel container that is approximately the size of a 2-liter bottle.

Legislation and Government Programs

In July 2010, the U.S. Environmental Protection Agency (EPA) promulgated a significant new use rule under section 5(a)(2) of the Toxic Substances Control Act of 1976 for elemental mercury used in flow meters, natural gas manometers, and pyrometers, for devices in service after September 11, 2009. This action required manufacturers and importers to notify the EPA at least 90 days before beginning the technique or process that required the use of mercury. The notification would provide the EPA with the opportunity to evaluate the intended use, and if necessary, limit or prohibit the activity (U.S. Environmental Protection Agency, 2010a).

The EPA issued final rules on cutting emissions of mercury and particle pollution from portland cement kilns, which are a leading source of mercury air emissions in the United States. The action sets limits on mercury emissions from existing kilns, strengthens the limits for new kilns, and limits particle pollution. When the final rules are fully implemented in 2013, the EPA estimated that annual emissions of mercury will be reduced by 92%, or 7 t (U.S. Environmental Protection Agency, 2010b).

In July 2009, the U.S. Food and Drug Administration (FDA) classified mercury-containing dental amalgam as a moderate risk item that released levels of mercury not high enough to cause harm and chose not to require warnings. However, in response to consumer petitions and letters, the FDA and an advisory panel of outside experts decided to review the existing scientific evidence that resulted in the FDA's earlier pronouncement that dental fillings containing mercury do not cause harm to patients. The review was scheduled for completion in early 2011 (Zajac, 2010).

The EPA announced that it intended to propose a rule that would be finalized in 2012 to reduce dental mercury waste, which was estimated to account for 3.7 metric tons per year (t/yr) of discharge. Until the rule is finalized, EPA encouraged dental offices to voluntarily install amalgam separators; these separators can capture 95% of the mercury that is discharged from dental offices for shipment to waste treatment plants (U.S. Environmental Protection Agency, 2010c).

The Mercury Export Ban Act of 2008 (Public Law 110–414), also known as MEBA, prohibited sale and transfer of elemental mercury after January 1, 2013, and addressed long-term storage of elemental mercury. The three main provisions are—Federal agencies are prohibited from selling or distributing elemental mercury, including stockpiles held by the U.S. Department of Energy (DOE) and U.S. Department of Defense; export of elemental mercury is banned beginning January 1, 2013; and the DOE will designate one or more facilities for long-term management and storage of elemental mercury generated within the United States. However, there are exemptions to the export ban for essential uses, and any person residing in the United States may petition the EPA for an exemption.

Electronic waste, or "e-waste," may contain arsenic, beryllium, mercury, and other hazardous materials. Incineration of the e-waste volatilizes and sends the chemicals into the environment; therefore, Vermont has passed legislation designed to provide a consistent and organized approach for handling of e-waste and make disposal in landfills illegal. Vermont solid waste districts took in 725 t of electronic waste in 2008 (Metal-Pages, 2010e).

Because of a mercury spill in October from a smelter in British Columbia, Canada, the EPA was engaged in a court case regarding pollution and cleanup along sections of the Columbia River, near the border of Washington State and Canada. The company has begun an investigation to determine the amount discharged, the cause of the spill, and the impact on the Columbia River. The court case was apparently settled, with a ruling that pollution was coming from old slag piles at the site and was subject to regulation under Superfund laws (Metal-Pages, 2010c).

The Federal Government sued eight metal companies in an attempt to recover $7 million spent by the EPA after 2004 to clean up mercury at Rye Brook, NY, which was part of the Port Refinery Superfund site. The lawsuit claimed that from the 1970s until 1991, Port Refinery was engaged in refining mercury. From 1991 to 1996, the EPA began an initial cleanup of mercury at the site. In 2004, nearby residents discovered mercury alongside a walkway. Since 2004, the EPA has removed 9,300 t of mercury-contaminated soil from the site (Metal-Pages, 2010d).

Using provisions from the Clean Air Act, the EPA published the national emissions standards for hazardous air pollutants, which was focused on gold-silver production facilities, the seventh leading source of mercury air emissions in the United States. The rule established mercury emissions limits for ore pretreatment, carbon processes with mercury retorts, carbon processes without mercury retorts, and noncarbon concentrate processes—the latter three processes separate gold from the ore. The EPA estimated that the rule would reduce mercury emissions by 0.7 t or a 77% reduction from 2007 levels (U.S. Environmental Protection Agency, 2010d). The new regulations permit only 38 kg of mercury emissions for every 1 million metric tons (Mt) of ore processed, whereas existing plants now produce approximately 59 kg of mercury emissions per 1 Mt of ore. The regulations affect mines in Alaska, Colorado, Montana, Nevada, and Washington (Kosich, 2010).

Research by the U.S. Department of Agriculture has shown that in laboratory experiments, activated carbon made from chicken and turkey litter manure removed the majority of elemental mercury from a hot air stream. The quantity of poultry manure produced annually is large, and these sorbent studies may be applicable to the reduction of mercury emissions from air, coal-fired powerplants, and natural gas (Klasson and others, 2009).

The U.S. Geological Survey conducted field studies in the South Yuba River in the western part of the Sierra Nevada Mountains, CA. The area is contaminated with mercury that was released during placer gold-silver mining that took place from the mid-1800s until the early 1900s. Resource managers and stakeholders in the region were concerned with the remobilization of the mercury from the sediments, its chemical form, potential for methylmercury production, and bioaccumulation of mercury in downstream environments. Fine-grained sediments contained the highest concentration of mercury and those fine-grained sediments were susceptible to long-range transport and elevated mercury content in the downstream environment (Fleck and others, 2011; Marvin-DiPasquale and others, 2011).

The National Defense Stockpile (NDS) held an inventory of 4,436 t of mercury at several sites in the United States. Mercury sales from the NDS were suspended in 1994 in response to environmental concerns. In 2004, the Defense Logistics Agency, DLA Strategic Materials (DLA) indicated that the mercury would be consolidated at one site in Nevada (Joseph Johnson, specialist, Defense Logistics Agency, written commun., April 30, 2004). The DOE has 1,329 t of mercury in storage facilities in Oak Ridge, TN.

Production

In 2010, byproduct mercury was produced at several precious metals mines in Nevada and was imported from foreign sources. Bethlehem Apparatus Co. Inc. (Bethlehem, PA) processed and refined mercury for resale. Data on the amount of byproduct mercury produced in the United States were not available. Mercury has not been mined as a principal product in the United States since 1992, when the McDermitt Mine in Nevada closed.

Consumption

In 2010, less than 100 t of mercury was consumed domestically. Domestic mercury consumption was broadly estimated to be about 50% for chlorine-caustic soda manufacture and 50% for other uses (Brooks and Matos, 2005, p. 3). Compact fluorescent lamps (CFLs), which contain 3 to 5 milligrams (mg) of mercury, were promoted as alternatives to standard fluorescent lamps (Von Ahn, 2007).

Global human health and environmental concerns about mercury have caused a decline in mercury purchases by the chlorine-caustic soda industry as well as an overall market shift in the chlorine-caustic soda industry from mercury cell technology toward nonmercury chlorine production technology. Since 1995, total annual mercury used by the industry has been reduced by 97%. In 1996, there were 14 operating mercury cell plants in the United States. Only four mercury-cell facilities were in operation in the United States at yearend 2009; these included mercury-cell facilities in Georgia, Ohio, Tennessee, and West Virginia (Lydersen, 2009). Mercury use at yearend 2008 was 4 t and mercury purchases were 1.2 t; however, mercury purchases do not equate to mercury use owing to process upgrades and longer piping runs that require more mercury. As mercury-cell plants close around the world, that mercury, as well as mercury from remediation of the plant facilities and soil, will become available for recycling and sale.

Owing to the concern over the environmental impact of mercury, a stabilization process has been developed and patented in the United States (U.S. Patent No. 7,691,361). This process converts mercury into a high-purity mercury sulfide with the same physical and chemical characteristics of naturally occurring cinnabar. The mercury sulfide is then blended with polymers resulting in a red, 7 millimeter (mm) × 7 mm pellet that is suitable for land disposal. This product is currently acceptable for disposal in landfills in Canada and awaits certification from the EPA for disposal in the United States (Bethlehem Apparatus Co., Inc., undated).

Recycling

Mercury was reclaimed from end-of-service automobile convenience switches, dental amalgam, fluorescent lamps, laboratory and medical devices, mercury contaminated waste, and thermostats in 2010. The voluntary National Vehicle Mercury Switch Recovery Program (NVMSRP) was started in 2006 by the EPA to stop toxic emissions of mercury when cars are scrapped and then melted to make new steel. From 2006 through 2009, the NVMSRP was supported by payments to dismantlers from the auto and steel industries. Payments were as much as $4 per switch, and the cumulative amount of mercury kept out of furnaces was 3 t (Schaffer, 2009). Funding for the program was depleted in July 2009; however, payments will continue in States where they are required by law or that have a State-funded program (U.S. Environmental Protection Agency, undated). In 2010, 630 kg of mercury was recovered from nearly 631,000 switches. These switches and other mercury-containing materials were treated in multistep high-temperature retorts in which the mercury was first volatilized and then condensed for purification and sale (Brooks and Matos, 2005, p. 1). The NVMSRP was scheduled to continue until 2017.

The Energy Independence and Security Act of 2007 (Public Law 110–140) included a ban on the sale of incandescent bulbs by 2014 and added CFLs, which contain 3 to 5 mg of mercury, to the list of recyclable products. Lamp manufacturers and recyclers encouraged consumers to return the used CFLs for recycling by providing shipping materials or collection programs (National Electrical Manufacturers Association, 2008). All CFLs contain mercury; however, newer CFLs may contain 80% less mercury than earlier models (Caplan, 2009). In September 2010, the last major factory in the United States to make incandescent light bulbs closed (Whoriskey, 2010).

Byproduct mercury from domestic and foreign sources and mercury reclaimed from end-of-service products were processed or recycled in the United States and then sold into the international metals market. No data were available on the amount of mercury recycled from these respective sources.

In 2010, the major companies that recycled mercury included AERC.com, Inc., Allentown, PA; Bethlehem Apparatus Co., Inc., Bethlehem, PA; Clean Harbors Environmental Services, Inc., Braintree, MA; D.F. Goldsmith Chemical and Metal Corp., Evanston, IL; Onyx Environmental Services, Lombard, IL; and WM Mercury Waste, Inc., Union Grove, WI. Benivia LLC (Atlanta, GA) maintained a list of companies whose role was mainly collection of mercury-containing materials that would ultimately be moved on to the larger companies for reclamation of the mercury (Benivia LLC, undated).

In 2010, Thermostat Recycling Corp. (TRC) (Rosslyn, VA) announced a 28% increase in its overall thermostat collections. More than 700 new collection locations were added in 2010, and collection points included heating, ventilation, and air conditioning (HVAC) contractors and distributors, local governments, and retailers. Nearly 1 t of mercury was collected during the year. TRC collection sites in Maryland, California, Florida, and Pennsylvania were the leading States in the recovery of 175 kg, 85 kg, 60 kg, and 45 kg, respectively. Individual thermostats may contain 2.5 to 10 grams of mercury (Thermostat Recycling Corp., 2011).

Prices

The average domestic price of mercury was $1,075 per flask in 2010. The price quoted in Platts Metals Week began the year at $600 per flask in January and steadily rose to $1,950 per flask in December, a 325% increase. There was resistance from buyers but demand remained strong through the summer, particularly from countries where the mercury was used to produce gold from small-scale or artisanal mining (Mining Journal, 2010b). Increased gold prices in 2010, averaging $1,200 per troy ounce, resulted in an increase in the global demand for mercury for small-scale gold mining. For comparison, in 2000–03, the average price of gold was $310 per troy ounce and the average price of mercury was $140 per flask. The price of mercury is also affected by a diminished supply of mercury from recycled mercury-containing products, fluctuations in imports of byproduct mercury, and fluctuations in production of domestic byproduct mercury.

Although the chloralkali and battery industries continue to switch to nonmercury technology, availability of mercury for small-scale gold mining will not increase because of the effect of the U.S. mercury export ban and the European export ban that is to take effect in March 2011. However, if rumors of resumed Chinese mercury production are true, then prices may stabilize (Mining Journal, 2010a).

Foreign Trade

In 2010, mercury imports totaled 294 t and exports totaled 459 t. Chile (176 t) and Peru (102 t) were the leading sources of imported mercury, which was produced as a byproduct of large-scale precious metals mining. The Netherlands (295 t), Peru (38 t), and Vietnam (36 t) were the principal export destinations for mercury in 2010. Mercury exported to the Netherlands may be held in warehouses for sale and later shipment to other destinations. Mercury imports in 2010 were 43% more than those in 2009. Imports of mercury may vary from year to year, possibly owing to stockpiling of byproduct mercury produced at foreign precious metals smelters before shipment or upon closure of chlorine-caustic soda plants.

In 2010, a total of 23 t of amalgam was imported into the United States. This material is defined as mercury with one or more metals and may include mercury-containing caustic soda waste. Principal amalgam source countries were Bolivia (9 t), Germany (4 t), and the United Kingdom (4 t). A total of 203 t of amalgam was exported from the United States and principal destinations included Canada (32 t), Peru (29 t), Denmark (21 t), and Mexico (19 t).

World Review

In 2010, world mercury mine production was estimated to be 2,250 t. China (1,600 t) and Kyrgyzstan (250 t) were the world's leading producers of mercury while Chile (176 t) and Peru (102 t) were the leading producers of byproduct mercury. World production estimates have a high degree of uncertainty because most companies and countries may not report primary, byproduct, or secondary production data owing to environmental and health concerns. Quantities may appear erratic from year to year because of stockpiling of sufficient mercury for shipment.

European Union.—Euro Chlor (Brussels, Belgium), representing the European chlorine-caustic soda industry, took great interest in implementation of EU Regulation 1102/2008 regarding the ban on exports of mercury, certain mercury compounds, and safe storage of mercury. In a position paper, Euro Chlor affirmed that permanent underground storage facilities already exist and that storage of the mercury in sealed containers in salt mines is considered the safest option. Stabilization of mercury has been developed at a laboratory scale; however, Euro Chlor indicated that there is no proven technology to convert mercury into another form (Euro Chlor, 2010b). Euro Chlor continued to implement a voluntary agreement on phasing out mercury cell technology by 2020 and has met the requirement that quantities of mercury at chloralkali sites have to be reported by May 31, 2010. Several European plants have closed; however, European chloralkali producers still have 8,200 t of mercury in 14 countries (Euro Chlor, 2010c). When the EU export ban takes place on March 15, 2011, mercury sent to temporary or permanent facilities was expected to be reported (Euro Chlor, 2010a).

China.—In 2010, China was the world's leading producer of mercury. According to a draft plan released by the China Nonferrous Metals Industry Association, China will restrain production of 10 nonferrous metals, including mercury, to less than 41 Mt t by 2015 (Metal-Pages, 2010a).

Colombia.—Colombia was one of the world's leading users of mercury for small-scale gold (silver-platinum) production. From 10 to 20 t/yr of gold are produced from Colombia's small-scale mines and from 50 to 100 t of mercury may be emitted to the atmosphere when the mercury-gold amalgam is burned to volatilize the mercury and recover the precious metals (Metal-Pages, 2010b). High levels of mercury have been found in five species of fish from Buenaventura Bay, which is Colombia's largest Pacific port. This raised health and environmental concerns because the mercury appeared related to runoff from the Dagua River, where small-scale gold mining takes place (Los Angeles Times, The, 2010). The United Nations presented its Supporting Entrepreneurs for Sustainable Development prize to small-scale miners in Choco, in western Colombia, for nonmercury production of gold, or "green gold" (El Tiempo, 2010).

Laos.—Small-scale gold mining is widespread in Laos. Because much of the mining was illicit and unregulated, mercury contamination was suspected in much of the country. Mining was thought to take place in every Province, but Xieng Khouang, Vientiane, and Luang Prabang Provinces have the most gold mines (Earth Times, 2010).

Mexico.—Mercury reserves in Mexico were estimated to be 26,900 t, including mercury contained in tailings from operations during colonial time (14,900 t) and primary mercury deposits (11,700 t). Small-scale mercury production reportedly took place near Sierra Gorda, where as many as 200 small mines operated at San Felipe de Mercurio. Mexico has imported mercury from Peru and exported mercury to Argentina, Brazil, Colombia, and Peru (Castro Diaz, 2008, p. 9).

Peru.—In 2010, 102 t of byproduct mercury from Peru's large-scale gold-silver mines was recovered and shipped to the United States for processing, resale, and shipment to metals dealers in Europe. Much of that mercury was ultimately resold into the global market to be used for small-scale gold mining, chlorine-caustic soda production, and dental amalgam.

Mercury is used widely in Peru for small-scale gold mining, and implementations of recommendations from a field study by the EPA and Argonne National Laboratory (Argonne, IL) led to reduction of mercury emissions from the gold shops where the amalgam was burned (Habegger and others, 2008, p. 9). As a result of these studies, efforts have been made to address and formalize small-scale mining issues (Caretas Peru, 2010; El Peruano, 2010b). Because of environmental impact and human health concerns, the Government of Peru passed legislation (Decreto de Urgencia, No. 012–2010) that suspended permits for new mining concessions, defined areas prohibited for mining, addressed recovery of affected areas, and prohibited the use of gold dredges in the rivers (El Peruano, 2010a). In 2010, small-scale gold mining produced 16 to 18 t of gold and generated $850 million in Madre de Dios, the most well-known of the 13 small-scale gold mining regions of Peru, and 450 t of mercury was lost to the environment (El Comercio, 2011).

Philippines.—Mercury was also used in the Philippines for small-scale gold mining and the Government, with support from the United Nations Environment Programme, formulated a National Strategic Plan focused on use and emissions of mercury, mining and production of gold, and the human health and environmental implications (Ban Toxics, 2010).

Outlook

Global mercury use is expected to decline with the exception of mercury used in the CFL industry and in small-scale gold mining. If gold prices continue to rise, these increased prices are likely to cause increased demand for mercury in the small-scale gold mining industry. Rising gold prices may also result in increased artisanal mercury production, increased recycling of mercury-containing tailings, and reopening of abandoned mercury mines to provide mercury for small-scale gold mining. The increased gold prices may also stimulate gold exploration, resulting in the opening of new large-scale mines. This, in turn, would result in continued byproduct mercury production from the processing of precious metals ores from the large-scale mines. Worldwide mercury prices may also rise, especially given the upcoming ban on mercury exports from the European Union in 2011 and from the United States in 2013.

Gallium alloys may provide nontoxic substitutes for mercury in a wide variety of applications that include electrical switches, liquid mirror telescopes, pumps, and sensors. Gallium can be alloyed with a variety of metals that include silver, gold, lead, cesium, and tin (Taylor and Rancort, 1998). Specifically, galinstan, an alloy of gallium, indium, and tin, is liquid at room temperatures and, owing to the low toxicity of its component metals, is a replacement for mercury. Owing to its higher reflectivity and lower density than mercury, galistan is being considered as a replacement for mercury in liquid mirror telescopes for astronomy. Mercury-containing dental amalgam, which is less aesthetically pleasing, has declined in use, replaced by ceramic material with a more natural appearance. Closure of mercury cell chlorine-caustic soda production facilities worldwide, owing to pressure from international environmental and health organizations, was expected to result in release of large quantities of mercury for disposal, recycling, or storage.

Recycled mercury from mercury cell chlorine-caustic soda plants, byproduct mercury recovered from domestic and foreign precious metals operations, and mercury contained in the NDS are expected to be more than adequate to meet domestic needs.

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TABLE 1

SALIENT MERCURY STATISTICS[1]

(Metric tons unless otherwise specified)

		2006	2007	2008	2009	2010
United States:						
Secondary production, industrial		NA	NA	NA	NA	NA
Imports for consumption		94	67	155	206	294
Exports		390	84	732	753	459
Industry stocks, yearend:[2]		19	18	24	30	30[e]
Chloralkali		17	16	20	27	27[e]
Other		2	2	4	3	3[e]
Industrial consumption		38	31	NA	NA	NA
Price, average, free market[3]	dollars per flask	670	530	600	610[r]	1,076
World, mine production		1,150	1,200	1,820[r]	1,960[r]	2,250[e]

[e]Estimated. [r]Revised. NA Not available.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Stocks at consumer and dealers only.

[3] Source: Platts Metal Week.

TABLE 2

U.S. IMPORTS AND EXPORTS OF MERCURY, BY COUNTRY[1]

	2009		2010	
Country	Quantity, gross weight (metric tons)	Value (thousands)	Quantity, gross weight (metric tons)	Value (thousands)
Imports:				
Canada	5	$24	4	$17
Chile	88	195	176	389
Germany	14	970	11	779
Peru	92	104	102	102
Russia	7	42	--	--
Other	(2)[r]	13[r]	1	4
Total	206	1,350	294	1,290
Exports:				
Australia	21	340	31	515
Colombia	4	75	--	--
Guatemala	13	123	--	--
Guyana	4	15	16	326
India	107	1,280	14	229
Netherlands	414	5,560	295	4,080
Peru	110	1,580	38	818
Singapore	16	261	--	--
Vietnam	41	605	36	615
Other	23[r]	414[r]	29	242
Total	753	10,300	459	6,830

[r]Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

TABLE 3
U.S. IMPORTS AND EXPORTS OF AMALGAMS[1] OF PRECIOUS METALS, WHETHER OR NOT CHEMICALLY DEFINED, BY COUNTRY[2]

	2009		2010	
Country	Quantity, gross weight (metric tons)	Value (thousands)	Quantity, gross weight (metric tons)	Value (thousands)
Imports:				
Argentina	1	$12,200	2	$23,100
Bolivia	--	--	9	14,400
Germany	4	7,220	4	7,150
Mexico	3	6,130	2	4,830
United Kingdom	2	2,910	4	13,700
Other	4 r	2,810 r	2	6,730
Total	14	31,300	23	70,000
Exports:				
Canada	12	2,940	32	7,700
China	15	52,300	12	39,200
Denmark	(3)	14	21	69
France	1	6,360	1	8,890
Germany	11	14,200	18	14,800
Hong Kong	20	1,370	3	495
India	6	17,300	13	54,600
Japan	16	25,100	2	3,120
Korea, Republic of	5	5,460	2	14,300
Mexico	18	27,900	19	4,170
Netherlands	14	22,700	13	8,260
Peru	(3)	21	29	120
Singapore	3	4,010	4	7,240
Taiwan	1	14,000	7	17,700
Thailand	1	6,570	7	60,600
United Kingdom	4	4,950	5	9,440
Other	26 r	33,000 r	15	22,800
Total	154	238,000	203	274,000

rRevised. -- Zero.

[1] An alloy of mercury with one or more other metals.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Less than ½ unit.

TABLE 4
MERCURY: WORLD MINE PRODUCTION, BY COUNTRY[1, 2, 3]

(Metric tons)

Country	2006	2007	2008	2009	2010[e]
Chile	NA	NA	NA	88	176
China[e]	760	800	1,300 [r]	1,400	1,600
Finland	20	20	20	15	15
Kyrgyzstan	250	250	250	250	250
Mexico[e]	8	8	21	21	21
Morocco[e]	10	10	10	10	10
Peru, exports[4]	22	34 [e]	136	92 [r]	102
Russia[e]	50	50	50	50	50
Spain	NA	NA	NA	NA	NA
Tajikistan[e]	30	30	30	30	30
United States[4]	NA	NA	NA	NA	NA
Total	1,150	1,200	1,820 [r]	1,960 [r]	2,250

[e]Estimated. [r]Revised. NA Not available.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through April 20, 2011.

[3] Canada is thought to produce byproduct mercury, but information on its production is inadequate to make reliable estimates.

[4] Byproduct mercury.

MICA

By Jason Christopher Willett

Domestic survey data and tables were prepared by Rym Ferahtia, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Mica production increased in 2010 compared with that of 2009. In 2010, production of scrap and flake mica in the United States increased to 53,000 metric tons (t); this was more than 3% higher than that of 2009 (tables 1, 2). The quantity of ground mica sold or used by producers decreased slightly to about 75,600 t valued at $22.8 million (tables 1, 3). Essentially all sheet mica used in the United States was imported, and China, Brazil, Belgium, Austria, and Germany, in decreasing order by quantity, were the major suppliers (table 11). In 2010, consumption of muscovite block mica in the United States was 0.91 t, a decrease of 16% compared with that of 2009 (tables 1, 4). Consumption of mica splittings increased to 275 t in 2010 from 266 t (revised) in 2009 (tables 1, 5). Worked and unworked sheet mica exports decreased to 933 t in 2010 from 1,120 t in 2009, and the value increased to $16.1 million in 2010 from $15.7 million in 2009 (table 12). U.S. imports of worked and unworked sheet mica increased to 1,980 t in 2010 from 1,500 t in 2009, and the value increased to $16.4 million in 2010 from $14.5 million in 2009 (table 12).

The mica group represents 37 phyllosilicate minerals that have a layered or platy texture (Rieder and others, 1998, p. 43–45). The commercially important micas are muscovite and phlogopite, which are used in a variety of applications. Mica's value is based on several of its unique physical properties. The crystalline structure of mica forms layers that can be split or delaminated into thin sheets. These sheets are chemically inert, dielectric, elastic, flexible, hydrophilic, insulating, lightweight, platy, reflective, refractive, resilient, and range in opacity from transparent to opaque. Mica is stable when exposed to electricity, light, moisture, and extreme temperatures. Mica has superior electrical properties as an insulator and as a dielectric. It can support an electrostatic field while dissipating minimal energy in the form of heat, can be split very thin (0.025 to 0.125 millimeter) while maintaining its electrical properties, has a high dielectric breakdown, is thermally stable to 500 °C, and has corona resistance. Muscovite is the principal mica used by the electrical industry and is used in capacitors that are ideal for high frequency and radio frequency. Phlogopite mica remains stable at higher temperatures (to 900 °C) and is used in applications in which a combination of high-heat stability and electrical properties are required. Muscovite and phlogopite are used in sheet and ground forms.

Production

Domestic mine production data for mica are developed by the U.S. Geological Survey from four separate voluntary surveys. Of the 12 operations to which the "Crude Scrap and Flake Mica Production" (including sericite production) survey form was sent, 6 operations responded and 1 was closed. Of the 11 operations to which the "Ground Mica" (excluding low-grade ground sericite production) form was sent, 2 operations responded and 1 was closed. Of the five surveyed operations to which the "Mica Block and Film Consumption" form was sent, two operations responded. Of the nine surveyed operations to which the "Mica Splittings Consumption" form was sent, three operations responded. Consumption for the nonrespondents was estimated using prior-year production data. Individual company production and consumption data are withheld to avoid disclosing company proprietary data.

Scrap and Flake Mica.—In 2010, eight companies with eight mines in four States produced scrap and flake mica, excluding low-grade sericite. The United States was one of the world's principal producers, with production of about 53,000 t (tables 1, 2, 13). The producing States were, in descending order, South Dakota, North Carolina, Georgia, and Alabama. Mica was recovered from mica schist, high-quality sericite schist, weathered pegmatites, gemstone pegmatite (sheet only), and as a coproduct of feldspar and kaolin mining and processing operations.

Ground Mica.—In 2010, six companies operated nine grinding plants in three States; six plants produced dry-ground mica, and three produced wet-ground mica.

Dry-ground mica producers were Georgia Industrial Minerals, Inc. in Georgia, Pacer Corp. in South Dakota, and Kings Mountain Mining LLC, Piedmont Minerals Corp., and United States Gypsum Co. (a subsidiary of USG Corp.) in North Carolina.

Wet-ground mica producers were BASF Corp and Georgia Industrial Minerals, Inc. in Georgia and Kings Mountain Mining LLC in North Carolina.

Sheet Mica.—Sheet mica was produced as a byproduct from one mine in 2010. Small quantities of muscovite sheet and scrap mica were produced as a byproduct by Morefield Gem Mine, Inc. in Amelia County, VA. The pegmatite was mined primarily for gemstones and mineral specimens using underground methods. The mine also produced biotite and zinnwaldite mica for collectors.

Consumption

Ground Mica.—The leading domestic use of dry-ground mica was in joint compound for filling and finishing seams and blemishes in gypsum wallboard (drywall) (table 3). The mica acts as a filler and extender, provides smooth consistency, improves the workability of the compound, and provides resistance to cracking. In 2010, joint compound accounted for 75% of dry-ground mica consumption.

In the paint industry, ground mica is used as a pigment extender that also facilitates suspension, reduces chalking, prevents shrinking and shearing of the paint film, increases resistance of the paint film to water penetration and weathering, and brightens the tone of colored pigments. Mica also promotes paint adhesion in aqueous and oleoresinous formulations. Consumption in paint accounted for 3% of the dry-ground mica used in 2010.

Ground mica is used in the well-drilling industry as an additive to drilling muds. The coarsely ground mica flakes help prevent the loss of circulation by sealing porous sections of the drill hole. The monthly U.S. drill rig count has increased every month since July 2009. The average monthly drill rig count for 2010 was 1,541 or 455 operating rigs more than the average of 2009 but 339 less than the average of 2008 (Baker Hughes, 2011). Well drilling muds accounted for 11% of dry-ground mica use in 2010, a 31% increase compared with that of the previous year (table 3).

The plastics industry used dry-ground mica as an extender and filler, especially in parts for automobiles as lightweight insulation to suppress sound and vibration. Mica is used in plastic automobile fascia and fenders as a reinforcing material, providing improved mechanical properties and increased dimensional stability, stiffness, and strength. Mica-reinforced plastics also have high-heat dimensional stability, reduced warpage, and the best surface properties of any filled plastic composite. In 2010, consumption of dry-ground mica in plastic applications accounted for 3% of the market.

The rubber industry used ground mica as an inert filler and mold release compound in the manufacture of molded rubber products, such as tires and roofing. The platy texture acts as an antiblocking, antisticking agent. As a rubber additive, mica reduces gas permeation and improves resiliency.

Dry-ground mica is used in the production of rolled roofing and asphalt shingles, where it serves as a surface coating to prevent sticking of adjacent surfaces. The coating is not absorbed by freshly manufactured roofing because mica's platy structure is unaffected by the acid in asphalt or by weather conditions. Mica is used in decorative coatings on wallpaper, concrete, stucco, and tile surfaces. It also is used as an ingredient in flux coatings on welding rods, in some special greases, and as coatings for core and mold release compounds, facing agents, and mold washes in foundry applications.

Dry-ground phlogopite mica is used in automotive brake linings and clutch plates to reduce noise and vibration (asbestos substitute); as sound-absorbing insulation for coatings and polymer systems; in reinforcing additives for polymers to increase strength and stiffness and to improve stability to heat, chemicals, and ultraviolet (UV) radiation; in heat shields and temperature insulation; in industrial coating additive to decrease the permeability of moisture and hydrocarbons; and in polar polymer formulations to increase the strength of epoxies, nylons, and polyesters.

Wet-ground mica, which retains the brilliancy of its cleavage faces, is used primarily in pearlescent paints by the automotive industry. In the cosmetics industry, its reflective and refractive properties make mica an important ingredient in blushes, eyeliner, eyeshadow, foundation, hair and body glitter, lipstick, lip gloss, mascara, moisturizing lotions, and nail polish. Mica is added to latex balloons to provide a colored shiny surface.

Natural mica is used by the Taos and Picuris Pueblos Indians in north-central New Mexico to make pottery. The pottery is made from weathered pre-Cambrian mica schist and has flecks of mica throughout the vessels. Tewa Pueblo pottery is made by coating the clay with mica to provide a dense-glittery micaceous finish over the entire object.

Built-Up Mica.—Muscovite and phlogopite splittings were fabricated into various built-up mica products by seven companies that operated seven plants in five States. Produced by mechanized or hand setting of overlapping splittings and alternate layers of binders and splittings, built-up mica is used primarily as an electrical insulation material. Mica insulation is used in high-temperature and fire-resistant power cable in aluminum plants, blast furnaces, critical wiring circuits (for example, defense systems, fire and security alarm systems, and surveillance systems), heaters and boilers, lumber kilns, metal smelters, and tanks and furnace wiring. Specific high-temperature mica-insulated wire and cable is rated to work for up to 15 minutes in molten aluminum, glass, and steel. Major products are bonding materials; flexible, heater, molding, and segment plates; mica paper; and tape (table 6).

Flexible plate (cold) is used in electric motor and generator armatures, field coil insulation, and magnet and commutator core insulation. In 2010, mica consumption in flexible plate was an estimated 16 t, or a decrease of 7% compared with that of 2009 (table 6).

Heater plate is used where high-temperature insulation is required. Consumption of heater plate mica increased by 3% in 2010 compared with that of 2009 (table 6).

Molding plate is sheet mica from which V-rings are cut and stamped for use in insulating the copper segments from the steel shaft ends of a commutator. Molding plate is also fabricated into tubes and rings for insulation in armatures, motor starters, and transformers. Consumption for molding plate increased by 5% to an estimated 45 t in 2010 (table 6).

Segment plate acts as insulation between the copper commutator segments of direct-current universal motors and generators. Phlogopite built-up mica is preferred because it wears at the same rate as the copper segments. Although muscovite has a greater resistance to wear, it causes uneven ridges that may interfere with the operation of a motor or generator. Consumption of segment plate was estimated to be about 147 t in 2010 (table 6).

Some types of built-up mica have the bonded splittings reinforced with cloth, glass, linen, muslin, plastic, silk, or special paper. These products are very flexible and are produced in wide, continuous sheets that are either shipped, rolled, or cut into ribbons or tapes, or trimmed to specified dimensions. Built-up mica products may also be corrugated or reinforced by multiple layering.

In 2010, the total amount of built-up mica that was consumed or shipped was estimated to be about 283 t. Segment plate and molding plate were the major end products and accounted for 52% and 16% of the total, respectively (table 6).

Mica Paper (Reconstituted Mica).—Primary uses for mica paper are the same as those for built-up mica. Five companies consumed scrap mica to produce mica paper for electrical and insulation applications. The principal source of the scrap was India. In 2010, the manufacturing companies were Asheville-Schoonmaker Mica Co., Newport News, VA; Corona Films Inc., West Townsend, MA; Isovolta Inc./US Samica Corp., Rutland, VT; Spruce Pine Mica Co., Spruce Pine, NC; and Tar Heel Mica Co., Inc., Plumtree, NC.

Sheet Mica.—Sheet mica is used principally in the electronics and electrical industries. Its usefulness in these applications is derived from its unique electrical and thermal insulating properties and its mechanical properties, which allow it to be cut, punched, stamped, and machined to close tolerances.

The leading use of block mica is as an electrical insulator in electronics equipment. High-quality block mica is processed to line the gauge glasses of high-pressure steam boilers because of its flexibility, transparency, and resistance to heat and chemical attack. Other uses include diaphragms for oxygen-breathing equipment, marker dials for navigation compasses, optical filters, pyrometers, retardation plates in helium-neon lasers, thermal regulators, and stove and kerosene heater windows. Specialized applications for sheet mica are found in aerospace components in air-, ground-, and sea-launched missile systems, laser devices, medical electronics, optical instrumentation, radar systems, radiation detector windows that are transparent to alpha emissions (Geiger-Mueller tubes), and for radiation treatment.

Only high-quality muscovite film mica, which is variously called India ruby mica or ruby muscovite mica, is used as a dielectric in capacitors. The highest quality mica film is used to manufacture capacitors for calibration standards. The next lower grade is used in transmitting capacitors. Receiving capacitors use a slightly lower grade of high-quality muscovite.

In 2010, fabrication of ruby and nonruby muscovite block consumed 0.91 t, about a 16% decrease from that consumed in 2009 (table 4). Stained and lower-than-stained quality muscovite remained in greatest demand and accounted for about 59% of consumption of ruby and nonruby mica block. Consumption of nonruby mica block was 63% for stained and lower-than-stained quality and 37% for good quality.

In 2010, mica splittings represented the largest part of the sheet mica industry in the United States. Consumption of muscovite and phlogopite splittings increased slightly to an estimated 275 t in 2010 (table 5). Muscovite splittings from India accounted for essentially all domestic consumption. The remainder was imported from China, Romania, and Japan.

Stocks

In 2010, reported yearend industry stocks of muscovite mica block (ruby and nonruby) were unchanged at 12.8 t. Industry stocks of muscovite and phlogopite mica splittings at an estimated 79 t were about 7% less than the previous year's level (table 5).

Prices

Sheet mica prices vary with grade and can range from less than $1 per kilogram for low-quality mica to more than $2,000 per kilogram for the highest quality. The estimated average values of mica block and splittings consumed in the United States in 2010 were as follows—muscovite block (ruby and nonruby) was $130 per kilogram and muscovite and phlogopite splittings were $1.53 per kilogram (tables 1, 5). Phlogopite block was $117 per kilogram and phlogopite splittings were $15 per kilogram.

In 2010, the average U.S. value of scrap and flake mica, which included high-quality sericite, was estimated to be $137 per metric ton (table 2). The average value for North Carolina flake mica was estimated to be $184 per ton. The average value of dry-ground mica was estimated to be $285 per ton, and the average value of wet-ground mica was estimated to be $700 per ton (table 1).

Foreign Trade

The value of U.S. exports of mica decreased by 6% to $24.7 million, and the quantity decreased by 19% to 7,410 t (table 12). Domestic ground mica (powder) exports decreased to 5,550 t, a decrease of 7% from that of 2009 (table 12). Ground mica exports decreased in value to $8.2 million in 2010 from $8.9 million in 2009. Exports of crude and rifted mica decreased by 58% to 291 t in 2010 from 688 t in 2009 (table 7). The value of crude and rifted mica exports decreased by 76% in 2010 compared with that of 2009.

U.S. imports of all mica totaled 28,400 t and were valued at $35.7 million, increases of 32% and 38%, respectively, compared with those of 2009. In 2010, total imports for consumption of unworked split block, film, splittings, and mica sheet categorized as "Other" doubled to about 3,830 t, almost all of which was comprised of unworked low-value scrap mica (less than $1.00 per kilogram) (table 9). Demand increased for the low-value mica used as a dry-ground additive for drywall compound, fillers, and paints. In 2010, 22,000 t of powder mica was imported, mostly from Canada, China, and Finland, about 6,100 t more than in 2009, or an increase of 30% (table 10). Worked mica imports were 1,930 t, a 30% increase from those of 2009 (table 11).

World Review

World production of mica was estimated to have increased to 1.07 million metric tons (Mt) in 2010 from 1.02 Mt in 2009. Most countries for which reported data were available reported increases in production in 2010 compared with that of 2009. All previous world production totals were revised and have increased significantly because of the inclusion of production data from China (table 13).

Outlook

The early production estimates for 2011 show an increase in crude mica production. Some other construction materials producers are reporting slight increases in production during the first 9 months of 2011. The major markets for ground mica—drywall joint compounds and paints—are mature and relatively stable, with growth tied to new housing starts and interest rates. When the housing market recovers, the long-term outlook for ground mica is for an expected production growth of 1% to 3% per year. Demand is also affected by automobile production because interior and exterior parts typically contain dry-ground mica or engineered mica composites, and exterior surfaces are painted with wet-ground pearlescent pigments and mica-containing coatings. The North American automobile industry rebounded much quicker than housing, and vehicle production was forecast to increase by about 7% in 2011 (Thomson Reuters, 2011).

As the economy recovers, demand for ground mica in smaller specialty markets such as coated micas, cosmetics, nylon and polyester resins, and polypropylene composites was expected to resume annual growth at a rate slightly higher than the rate for the entire ground mica industry during the next decade.

Demand for block mica was expected to increase slowly at about 1% per year during the next several years as demand increases in a few specialty markets, such as electronics. A shortage of high-quality block mica was expected to continue because of the generally low percentage of high-quality mica in deposits currently being mined, mostly pegmatites.

Consumption of mica splittings, which is the principal type of sheet mica consumed in the United States, has been in the range of 300 to 400 metric tons per year (t/yr) in recent years, although it was estimated to have dipped below 300 t/yr to 275 t/yr in 2010. With no potential new uses apparent and many substitute materials being used, substantial growth is not expected.

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TABLE 1

SALIENT MICA STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Production, sold or used by producers:						
Scrap and flake mica:						
Quantity	thousand metric tons	110	97	85 [r]	51 [r]	53
Value	thousands	$22,400	$14,400	$10,200 [r]	$6,530 [r]	$7,240
Ground mica:						
Quantity	thousand metric tons	123	99	98	77	76
Value	thousands	$49,000	$26,400	$26,500	$23,200	$22,800
Prices:						
Scrap and flake mica	dollars per metric ton	204	149	120 [r]	128 [r]	137
Ground:						
Dry	do.	237	243	251	284	285
Wet	do.	784	683	651	651	700
Sheet, muscovite and phlogopite:						
Block	dollars per kilogram	130	132	122	121 [r]	130
Splittings	do.	1.53	1.57	1.53	1.66 [r]	1.53
Consumption:						
Block, muscovite:						
Quantity	metric tons	1	1	1	1	1
Value	thousands	$146	$139	$127	$131	$117
Splittings, all types						
Quantity	metric tons	310	310	308	266 [r]	275
Value	thousands	$475	$475	$471	$440 [r]	$421
Exports	metric tons	8,620	9,010	11,100	9,150	7,410
Imports	do.	46,900	43,000	28,800	21,400	28,400
World, production[e]	do.	1,090,000 [r]	1,120,000 [r]	1,140,000 [r]	1,020,000 [r]	1,070,000

[e]Estimated. [r]Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits.

TABLE 2
SCRAP AND FLAKE MICA SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

State	2008		2009		2010	
	Quantity	Value[r]	Quantity	Value[r]	Quantity	Value
North Carolina	22	4,460	17 [r]	3,400	20	3,590
Other[3]	64 [r]	5,780	34	3,130	33	3,650
Total	85 [r]	10,200	51 [r]	6,530	53	7,240

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes finely divided mica recovered from mica schist and high-quality sericite schist, and mica that is a byproduct of feldspar and kaolin beneficiation.

[3] Includes Alabama, Georgia, and South Dakota.

TABLE 3
GROUND MICA SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY END USE AND METHOD OF GRINDING[1, 2]

	2008			2009			2010		
	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
End use:									
Joint compound	53	$12,800	$246	47	$12,200	$256	44	$11,200	$256
Paint	22	7,180	324	17	6,440	384	17	6,440	384
Plastics	2	1,390	697	2	1,360	642	2	1,370	660
Well-drilling mud	15	2,790	181	5	943	191	7	1,160	176
Other[3]	6	2,320	386	6	2,290	381	6	2,660	419
Total	98	26,500	271	77	23,200	301	76	22,800	302
Method of grinding:									
Dry	W	W	251	W	W	284	W	W	285
Wet	W	W	651	W	W	651	W	W	700

W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Domestic and some imported scrap. Low-quality sericite is not included.

[3] Includes mica used for molded electrical insulation, roofing, rubber, textile and decorative coatings, welding rods, and miscellaneous.

TABLE 4
FABRICATION OF MUSCOVITE BLOCK MICA IN THE UNITED STATES, BY QUALITY[1]

(Kilograms)

	2008	2009	2010
Good stained or better	420	416	370
Stained or lower than stained[2]	624	665	536
Total	1,040	1,080	906

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes punch mica.

TABLE 5
ESTIMATED CONSUMPTION AND STOCKS OF MICA SPLITTINGS IN THE UNITED STATES

	Consumption		Stocks on
Year	Quantity (metric tons)	Value (thousands)	December 31 (metric tons)
2008	308	$471	110 ^{r}
2009^{r}	266	440	84
2010	275	421	79

^{r}Revised.

TABLE 6
ESTIMATED BUILT-UP MICA SOLD OR USED IN THE UNITED STATES, BY PRODUCT[1,2]

	2008		2009		2010	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Flexible plate (cold)	21	$154 ^{r}	17 ^{r}	$131 ^{r}	16	$132
Heater plate	9	55	1	24	1	35
Molding plate	65	431	44 ^{r}	313	45	333
Segment plate	149	288	147	278	147	279
Tape	W	W	W	W	W	W
Other	107 ^{r}	503 ^{r}	69 ^{r}	240 ^{r}	72	314
Total	351	1,430	278	985 ^{r}	283	1,090

^{r}Revised. W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Consists of alternating layers of binder and irregularly arranged and partly overlapped splittings.

TABLE 7

U.S. EXPORTS OF CRUDE AND RIFTED MICA, MICA POWDER, AND WASTE, BY COUNTRY[1]

Country	Crude and rifted				Powder		Waste	
	Less than $1 per kilogram		More than $1 per kilogram					
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009	369	$105	319	$1,370	5,940	$8,850	1,500	$569
2010:								
Algeria	--	--	--	--	233	164	--	--
Argentina	--	--	18	33	25	140	--	--
Bahamas, The	97	21	24	92	--	--	--	--
Belgium	--	--	--	--	96	405	--	--
Brazil	--	--	--	--	382	651	--	--
Canada	15	5	--	--	948	1,170	690	257
Chile	6	6	--	--	2	7	--	--
China	--	--	--	--	41	233	--	--
Colombia	--	--	--	--	273	252	--	--
Dominican Republic	--	--	2	10	17	8	--	--
France	--	--	--	--	43	253	--	--
Germany	--	--	--	--	260	860	--	--
Hong Kong	--	--	--	--	21	56	--	--
Hungary	--	--	1	4	--	--	--	--
India	--	--	--	--	14	38	--	--
Israel	--	--	1	4	--	--	--	--
Italy	16	10	--	--	54	52	--	--
Japan	--	--	5	15	349	683	--	--
Korea, Republic of	--	--	--	--	474	369	--	--
Mexico	--	--	2	4	1,570	1,200	--	--
Netherlands	--	--	7	11	285	717	--	--
New Zealand	--	--	--	--	(2)	12	7	13
Nigeria	--	--	--	--	53	20	--	--
Peru	--	--	--	--	49	76	--	--
Philippines	--	--	--	--	37	32	--	--
Saint Lucia	--	--	--	--	--	--	--	--
Singapore	--	--	--	--	26	88	--	--
Spain	--	--	--	--	35	114	--	--
Taiwan	--	--	3	12	23	34	--	--
Thailand	80	64	--	--	9	30	--	--
United Arab Emirates	--	--	--	--	20	9	--	--
United Kingdom	--	--	13	60	35	47	--	--
Venezuela	--	--	--	--	48	79	--	--
Other	--	--	1	12	124	395	--	--
Total	214	107	77	255	5,550	8,190	697	270

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8

U.S. EXPORTS OF WORKED MICA, BY COUNTRY[1]

Country	Plates, sheets		Other	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009	601	$9,000	417	$6,310
2010:				
Aruba	4	43	1	43
Austria	2	49	237	1,500
Bahamas, The	--	--	6	46
Brazil	25	556	6	182
Canada	114	2,700	78	2,500
China	14	440	51	412
Colombia	12	644	4	95
France	17	598	4	173
French Polynesia	3	18	--	--
Germany	9	195	(2)	9
India	2	130	--	--
Israel	11	24	--	--
Jamaica	4	16	--	--
Japan	3	111	32	268
Korea, Republic of	19	321	--	--
Lithuania	4	112	--	--
Mexico	51	1,140	19	738
Netherlands	7	124	--	--
Peru	4	101	--	--
Switzerland	23	448	--	--
Taiwan	28	483	14	369
Trinidad and Tobago	9	171	--	--
United Arab Emirates	15	137	(2)	6
United Kingdom	20	170	(2)	11
Other	19	540	6	311
Total	419	9,270	460	6,660

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9

U.S. IMPORTS FOR CONSUMPTION OF CRUDE AND RIFTED MICA, BY COUNTRY[1]

Country	Split block		Splittings		Other			
					Less than $1 per kilogram		More than $1 per kilogram	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009	(2)	$17	20	$67	1,900	$1,030	2	$33
2010:								
Belgium	--	--	--	--	--	--	1	39
Canada	--	--	--	--	20	4	--	--
China	--	--	1	10	--	--	11	52
India	--	--	36	67	3,750	1,790	5	67
Japan	--	--	(2)	6	--	--	--	--
Romania	--	--	1	5	--	--	--	--
Total	--	--	39	89	3,770	1,790	16	158

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10

U.S. IMPORTS FOR CONSUMPTION OF MICA POWDER AND WASTE, BY COUNTRY[1]

	Powder		Waste	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009	16,900	$9,540	1,090	$662
2010:				
Canada	10,200	4,410	17	9
China	6,860	1,650	--	--
Finland	3,600	976	--	--
Germany	122	228	--	--
India	83	4,980	583	476
Japan	762	4,260	--	--
Korea, Republic of	60	10	--	--
Netherlands	79	25	23	39
Norway	64	69	--	--
United Kingdom	61	104	--	--
Other	92	199	--	--
Total	22,000	16,900	623	525

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 11

U.S. IMPORTS FOR CONSUMPTION OF WORKED MICA, BY COUNTRY[1]

	Plates, sheets		Other	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009	1,100	$12,000	385	$2,450
2010:				
Austria	139	3,300	17	570
Belgium	290	2,970	--	--
Brazil	350	1,910	356	720
Canada	24	100	--	--
China	411	2,090	64	313
France	31	452	(2)	30
Germany	34	530	1	52
India	24	413	102	715
Japan	6	401	(2)	70
Switzerland	9	165	(2)	10
United Kingdom	32	617	27	622
Other	6	127	3	49
Total	1,360	13,100	572	3,150

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 12

SUMMATION OF U.S. MICA TRADE DATA[1]

	Scrap and flake mica				Sheet mica			
	Powder		Waste		Unworked		Worked	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Exports:								
2009	5,940	$8,850	2,090	$1,600	96	$437	1,020	$15,300
2010	5,550	8,190	935	468	53	163	879	15,900
Imports for consumption:								
2009	16,900	9,540	2,990	1,670	23	142	1,480	14,400
2010	22,000	16,900	4,400	2,390	51	180	1,930	16,200

[1] Data are rounded to no more than three significant digits.

Source: U.S. Census Bureau.

TABLE 13

MICA: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Argentina, all grades	6,233	10,171	8,790	8,668	9,000
Brazil[e]	4,000	4,000	4,000	4,000	4,000
Canada[e]	17,500	18,000	17,000	15,000	15,000
China	700,000	720,000	750,000	700,000	750,000
Finland					
Concentrate	8,097	11,449 [r]	10,706 [r]	10,000 [r]	10,000
Biotite	62,959	60,000	60,000	60,000	60,000
Total	71,056	71,449 [r]	70,706 [r]	70,000 [r]	70,000
France[e]	20,000	20,000	20,000	20,000	20,000
India:[e]					
Crude	1,590 [r]	3,790 [r]	2,050 [r]	2,000 [r]	2,100
Scrap and waste	3,570 [r]	3,420 [r]	4,470 [r]	4,500 [r]	4,700
Total	5,150 [r]	7,210 [r]	6,520 [r]	6,500 [r]	6,800
Iran[e, 4]	--	1,800	1,510 [r, 5]	1,500 [r]	1,500
Korea, Republic of, all grades	30,356	42,385	49,474	27,078	27,000
Madagascar, phlogopite	1,071	1,349	1,233	358	800
Malaysia	5,152	6,118	5,593	4,323	4,500
Mexico, all grades	150	9,600 [r]	5,000 [r]	5,000 [r]	160 [p]
Norway, flake[e]	2,600	2,600	2,600	2,600	2,500
Peru[e]	61	60	91 [5]	84 [5]	85
Russia[e]	100,000	100,000	100,000	100,000	100,000
Serbia[e]	200	200	200	200	200
South Africa, ground and scrap	828	437	393	299	442 [5]
Spain	4,496	5,569 [r]	4,254 [r]	4,000 [r, e]	4,500
Sri Lanka, scrap	2,600	3,224	2,364 [r]	2,800 [r]	2,900
Taiwan	4,841	3,387	3,179	557	-- [5]
United States, scrap and flake[6]	110,000	96,600	85,300 [r]	51,200 [r]	52,800 [5]
Grand total	1,090,000 [r]	1,120,000 [r]	1,140,000 [r]	1,020,000 [r]	1,070,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 21, 2011.

[3] In addition to the countries listed, Pakistan, Romania, and Sweden are known to produce mica, but available information is inadequate to make reliable estimates of output levels.

[4] Year beginning March 21 of that stated.

[5] Reported figure.

[6] Excludes, if any, U.S. production of low-quality sercite and sheet mica.

MOLYBDENUM

By Désirée E. Polyak

Domestic survey data and tables were prepared by Raymond I. Eldridge III, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In the United States, mine production of molybdenum concentrate in 2010 increased by 24% to 59,400 metric tons (t) from the 47,800 t of 2009 (table 1). Estimated world mine production of molybdenum in 2010 was about 242,000 t, a 9% increase from 221,000 t in 2009. The U.S. share of world production was 25% in 2010. Reported U,S. consumption of molybdenum concentrate for roasting in 2010 increased by 26% compared with that of 2009.

Molybdenum is a refractory metallic element used principally as an alloying agent in cast iron, steel, and superalloys to enhance hardenability, strength, toughness, and wear- and corrosion-resistance. To achieve desired metallurgical properties, molybdenum, primarily in the form of molybdic oxide (MoO_3, called MoX) or ferromolybdenum (FeMo), is frequently used in combination with or added to chromium, manganese, nickel, niobium (columbium), tungsten, or other alloy metals. The versatility of molybdenum in enhancing a variety of alloy properties has ensured it a significant role in contemporary industrial technology, which increasingly requires materials that can sustain high stress, expanded temperature ranges, and highly corrosive environments. There is significant use of molybdenum as a refractory metal and in numerous chemical applications, including catalysts, lubricants, and pigments.

U.S. molybdenum reserves were estimated to be about 2.7 million metric tons (Mt), about 31% of the world molybdenum reserves. About 90% of U.S. reserves occur in large low-grade porphyry molybdenum deposits mined or anticipated to be mined primarily for molybdenum and as an associated metal sulfide in low-grade porphyry copper deposits. These deposits are in Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Utah. Other molybdenum sources do not contribute significantly to U.S. reserves.

Production

Domestic molybdenum production data were derived from three separate voluntary surveys by the U.S. Geological Survey. These surveys are "Molybdenum Ore and Concentrate" (annual), "Molybdenum Concentrate" (monthly), and "Molybdenum Products and Molybdenum Concentrates" (monthly). Surveys were sent to all 10 U.S. operations that currently produce molybdenum concentrates and products from ore, and all responded, representing 100% of the U.S. production listed in table 1.

As of December 31, 2010, U.S. rated capacity for mines and mills was estimated to be about 73,800 metric tons per year (t/yr) of contained metal. Rated capacity was defined as the maximum quantity of product that could be produced in a period of time at a normally sustainable long-term operating rate based on the physical equipment of the plant and given acceptable routine operating procedures involving energy, labor, maintenance, and materials. Capacity included operating plants temporarily closed, which could be brought into production within a short period of time with minimal capital expenditure.

Primary molybdenum production continued at the Ashdown Mine in Nevada, the Henderson Mine in Colorado, the Questa Mine in New Mexico, and the Thompson Creek Mine in Idaho. The Ashdown Mine, in Humboldt County, produced 96 t of molybdenum in 2010. The company announced that it had developed access to additional reserves, and in 2011 was expected to raise production rates to 2008 levels of roughly 46 t of molybdenum per quarter (CNW Group, 2011).

Freeport-McMoRan Copper & Gold Inc. (FCX) announced that its Henderson Mine produced 18,140 t of molybdenum in 2010, a 48% increase compared with 12,250 t produced in 2009. Henderson also produced 18,140 t of molybdenum in 2008. The Henderson underground mine produces high-purity, chemical-grade molybdenum concentrates, which typically are further processed into value-added molybdenum chemical products (Freeport-McMoRan Copper & Gold Inc., 2011a, p. 22, 106). The Henderson operation consists of a large underground mining complex feeding a concentrator with the capacity to produce approximately 18,200 t/yr of molybdenum (Freeport-McMoRan Copper & Gold Inc., 2011b, p. 13).

FCX announced that total consolidated molybdenum sales from Henderson Mine and byproduct production at its North American and South American copper mines totaled 30,390 t of molybdenum in 2010, a 16% increase compared with sales of 26,300 t of molybdenum in 2009. FCX attributed this increase to improved demand in the chemicals sector (Freeport-McMoRan Copper & Gold Inc., 2011a, p. 22, 25).

FCX announced that construction activities at its idle Climax molybdenum mine were expected to continue into 2011. In 2010, concrete foundations for various equipment installations were completed, and the ball mill shell assembly commenced. The company announced that startup of mining and milling activities would be dependent on market conditions. The Climax Mine had an initial design capacity of 13,600 t/yr of molybdenum, with significant expansion options. The estimated remaining costs for the project were approximately $450 million (Freeport-McMoRan Copper & Gold Inc., 2011c).

Thompson Creek Metals Company Inc. (TCMC) owns the Thompson Creek open pit molybdenum mine and mill near Challis, ID, a metallurgical roasting facility in Langeloth, PA, and a 75% share of the Endako open pit mine, mill, and roasting facility in northern British Columbia, Canada. The molybdenum concentrate produced at the Thompson Creek Mine is transported to the Langeloth facility, which produces ferromolybdenum products, molybdenum trioxide, and other specialty products. The Langeloth facility also processes nonmolybdenum catalysts for various customers, primarily in the food industry. TCMC had two high-grade underground molybdenum deposits, the Davidson deposit near Smithers, British Columbia, Canada, and the Mount Emmons deposit near Crested Butte, CO (Thompson Creek Metals Company Inc., 2011, p. 42).

TCMC announced that its Thompson Creek Mine produced 11,370 t of molybdenum in 2010, a 41% increase from the 8,080 t of molybdenum produced in 2009. The increase was primarily because of significantly higher grade of ore from the Thompson Creek Mine. The company expected the Thompson Creek Mine to have higher production for the first half of 2011 (6,350 to 6,800 t of molybdenum) than the last half of 2011 (3,630 to 4,080 t of molybdenum) mainly owing to the tapering off of higher grade production (Thompson Creek Metals Company Inc., 2011, p. 65–66).

Molybdenum was produced as a byproduct of copper production at the Bagdad, Mineral Park, and Sierrita Mines in Arizona; the Continental Pit Mine in Montana; the Robinson Mine in Nevada; and the Bingham Canyon Mine in Utah (table 10). The Morenci and Mission Mines in Arizona as well as the Chino Mine in New Mexico did not produce molybdenum in 2010. In the case of byproduct molybdenum recovery at a copper mine, all mining costs associated with producing molybdenum concentrate are allocated to the primary metal (copper). In 2010, byproduct molybdenite recovery accounted for approximately 50% of the U.S. molybdenum supply.

The Bagdad operation of FCX includes a 75,000 metric-ton-per-day (t/d) concentrator that produces copper and molybdenum concentrates, as well as a pressure leach plant that processes molybdenum concentrate. Molybdenum production at Bagdad in 2010 was 3,180 t, a 17% increase compared with 2,720 t of molybdenum in 2009 (Freeport-McMoRan Copper & Gold Inc., 2011b, p. 8).

The Sierrita operation of FCX includes a 102,000-t/d concentrator that produces copper and molybdenum concentrates. It also has molybdenum facilities consisting of a leaching circuit, two molybdenum roasters, and a packaging facility. The molybdenum facilities process concentrate from Sierrita, concentrate from other FCX mines, and concentrate from third-party sources. Molybdenum production at Sierrita in 2010 was 8,160 t of molybdenum, a 15% decrease compared with 9,620 t of molybdenum in 2009 (Freeport-McMoRan Copper & Gold Inc., 2011b, p. 9).

Rio Tinto plc (London, United Kingdom) announced that molybdenum concentrate production at its Bingham Canyon Mine (operated by Kennecott Utah Copper) was 12,900 t of molybdenum compared with 11,300 t of molybdenum in 2009 (Rio Tinto plc, 2011, p. 84). In April, Rio Tinto announced that its Kennecott Utah Copper operation launched construction of a $340 million molybdenum autoclave process facility that was expected to improve process efficiency and metal recovery, and to reduce greenhouse gas emission intensity. First production from phase I was anticipated in the fourth quarter of 2012, and full capacity of 13,600 t/yr of molybdenum was scheduled for the fourth quarter of 2013. The phase 2 expansion to 27,200 t/yr of molybdenum was anticipated to be completed in the first quarter of 2015. Kennecott also submitted permits to move forward with the Cornerstone project, which was expected to extend the life of its Bingham Canyon Mine and operations to 2028 (Rio Tinto plc, 2011, p. 47–48).

In March, General Moly Inc. announced that Hanlong (USA) Mining Investment Inc., a wholly owned subsidiary of Sichuan Hanlong Group (Hanlong), agreed to procure $745 million in debt and equity, which would fully fund the Mt. Hope project in central Nevada. General Moly has an 80% stake in the Mount Hope project, with reserves of 590,000 t of molybdenum and a mine life in excess of 40 years. The remaining 20% is owned by Pohang Iron and Steel Co. (POSCO), a firm based in Pohang, South Korea. Permitting, which began in 2006, was ongoing, and the company expected all work to be completed near the end of 2011 or early 2012. Initial production was expected approximately 20 months after construction has begun (General Moly Inc., 2011, p. 4–6).

In February 2011, Northern Dynasty Minerals Ltd. (Vancouver, British Columbia, Canada) announced the completion of a preliminary assessment of its Pebble copper-gold-molybdenum project in southwestern Alaska. The assessment confirmed that if just 32% of the site was developed, the project had the potential to produce approximately 14 Mt of copper and 635,000 t of molybdenum during a 45-year period. The preliminary assessment updated and substantially revised the project economic analysis last done by the company in 2004. A prefeasibility study was expected to be completed in 2012, prior to the completion of the permitting process under the National Environmental Policy Act (Northern Dynasty Minerals Ltd., 2011, p. 3).

Consumption

In 2010, U.S. reported consumption of molybdenum contained in concentrate for roasting was approximately 26% more than that of 2009 (table 1). Domestic mine production of molybdenum concentrate was roasted, exported for conversion, or purified to lubricant-grade molybdenum disulfide (MoS_2). Technical-grade MoX consumption in 2010 was 7% more than that of 2009. MoX was the leading form of molybdenum used by industry, particularly in making stainless steel. Overall, total Mo use in steel in 2010 increased by 16% from that of 2009, and use in superalloys in 2010 increased by 18% from that of 2009 (table 3).

Metallurgical applications dominated molybdenum use in 2010, accounting for about 88% of 2010 grand total reported consumption (table 3). In 2010, FeMo accounted for 36% of the molybdenum-bearing materials used to make steel. Nonmetallurgical applications included catalysts, chemicals, lubricants, and pigments. The dominant nonmetallurgical use was in catalysts.

Molybdenum is playing a more important role in green technology than ever before, with use focused on biofuels, catalysts, ethanol, solar panels, and wind power. In May, a team of researchers with the U.S. Department of Energy's Lawrence Berkeley National Laboratory and the University of California, Berkeley, announced the discovery of an inexpensive new proton reduction catalyst, seventy times less expensive than platinum commonly used now to produce hydrogen gas. The new catalyst was based on a molybdenum-oxo metal complex that generates hydrogen from water without the use of additional acids or organic solvents. These qualities were expected to make the catalyst ideal for renewable energy use (Karunadasa and others, 2010).

A new type of solar panel made of copper-indium-gallium-selenide (CIGS) cells contains molybdenum in a thin layer near the bottom of the cell. The molybdenum helps to transfer the electricity generated from the solar cell to circuits external to the panel. Although photovoltaic solar power capacity is small, CIGS technology has demonstrated the highest conversion efficiency and the longest product life within the solar power-production industry. Analysts estimate that CIGS cells use approximately 1,100 t of molybdenum per gigawatt of capacity (Compound Semiconductor, 2010).

Stocks

At yearend 2010, producer plus consumer industry stocks increased compared with yearend 2009 stocks. Inventories of molybdenum in concentrate at mines and plants decreased by about 360 t. Producer stocks of molybdenum in FeMo, molybdates, MoX, metal powders, and other products increased compared with producer stocks of 2009 (table 2).

Prices

Prices were reported in Platts Metals Week in dollars per pound of contained molybdenum. In January 2010, the average prices for MoX and FeMo were $14.50 per pound and $17.00 per pound, respectively. Prices slowly increased reaching a 2010 high of $17.58 per pound MoX and $21.69 per pound FeMo average for the month of April. Prices slightly fluctuated for the remainder of the year with an average price of $16.19 per pound MoX and $18.47 per pound FeMo for the month of December.

Foreign Trade

In 2010, molybdenum-containing material exports collectively contained about 11,700 t (gross weight) and were valued at $1.37 million (table 6). Imports for consumption of molybdenum-containing products collectively contained about 33,500 t (gross weight) and were valued at $576 million (table 9).

World Review

World molybdenum reserves and production capacity were concentrated in a few countries. World mine output in 2010 was estimated to have been 242,000 t (molybdenum contained in concentrate), of which, in descending order of production, China, the United States, Chile, Peru, Mexico, and Canada provided about 94% (table 11). Peru increased molybdenum production by about 40% from 2009 to 2010.

In North America, most Canadian reserves of molybdenum were contained in porphyry molybdenum and porphyry copper-molybdenum deposits in British Columbia. Other Canadian reserves were associated with minor porphyry copper-molybdenum deposits in New Brunswick and Quebec. The La Caridad porphyry copper-molybdenum deposit in Mexico was a leading producer. Molybdenum reserves in Central America and South America were associated mainly with large porphyry copper deposits. Of several such deposits in Chile, the Chuquicamata and El Teniente deposits were among the largest in the world and accounted for 85% of molybdenum reserves in Chile. Peru also had substantial reserves. Reserves of molybdenum in China and the Commonwealth of Independent States (CIS) were thought to be substantial, but definitive information about the current sources of supply or prospects for future development in these two areas was lacking.

According to a study performed by the International Molybdenum Association and by the Steel & Metals Market Research Company, in 2009, global Mo consumption in all applications was 212,000 t, which included new and recycled molybdenum. Most recycled Mo is introduced as scrap in steelmaking. Their analysis was based on more than 250 interviews with key Mo end users. For all applications, according to their study, approximately 15% of Mo input material originated from scrap. Molybdenum was used in the following end uses—engineering steels (34%), stainless steels (26%), chemical products (13%), tool and high-speed steels (10%), cast iron (7%), superalloys (5%), and Mo metal (5%) (International Molybdenum Association, 2011, p. 2).

Armenia.—Production and sales of molybdenum concentrate at the Karajan copper-molybdenum mine, managed by Zangezur Copper and Molybdenum Combine CJSC (ZCMC), a subsidiary of Cronimet Mining GmbH (Germany), increased by 2.3% to 8,800 t of molybdenum in 2010. The Karajan copper-molybdenum mine is in the southeastern corner of Armenia in the Province of Syunik. ZCMC was in the final stages of completing a multimillion dollar ore processing facility, which was expected to be one of the largest mills, by production capacity, in the CIS countries. According to the company, its main strategy was to have processing infrastructure for copper and molybdenum which meet Western standards (Mining Journal, 2011, p. 7).

Agarak Copper and Molybdenum Combine (ACMC), located in the southern Armenian Province of Syunik, was acquired by GeoProMining Ltd. (GPM) in 2007. According to the company, ACMC produced 254 t of molybdenum concentrates in the first 6 months of 2010. GPM announced that it planned to install new flotation machines and upgrade new equipment to increase its molybdenum recovery rate. The upgrades were anticipated to be completed in early 2012 (Mining Journal, 2011, p. 11).

Australia.—Moly Mines Ltd. (Perth, Australia) announced that mining activities were expected to start in August 2010 at its Spinifex Ridge molybdenum project in the Pilbara region of Western Australia. In April, Hanlong Mining Investment Pty. Ltd. became Moly Mines' controlling shareholder (55%), following the settlement of a $200 million equity and debt funding package (Moly Mines Ltd., 2010, p. 1). According to the company, site construction work had commenced and work on the Utah Point export facility was on schedule. The facility was expected to receive Spinifex Ridge ore at the end of October (Engineering and Mining Journal, 2010).

Moly Mines had initially planned to develop and operate a mining operation at Spinifex Ridge that would produce 20 million metric tons per year (Mt/yr) of molybdenum ore, based on a 24-year mine life. However, a dramatic fall in molybdenum prices in late 2008 led the company to revise its plans for a smaller 10-Mt/yr ore operation, with a possibility of future expansion (Engineering and Mining Journal, 2010).

In April, Ivanhoe Mines Ltd. announced it would start a prefeasibility study for its high-grade Merlin molybdenum and rhenium deposit, which comprises the Mt. Dore project in the Cloncurry District in northwestern Queensland, part of Ivanhoe Australia Ltd. (Vancouver, British Columbia, Canada). Environmental permitting was expected to be carried out in parallel with the prefeasibility study. Indicated resources total 6.5 Mt at a grade of 1.3% molybdenum and 23 grams per ton rhenium. Production was expected to produce approximately 5,300 t/yr of molybdenum and 7.5 t/yr of rhenium, with an initial mine life of 9 years. Production was expected to begin in the third quarter of 2012. Despite its high molybdenite content, the silicate nature of the Merlin ore might make it difficult to convert to salable high-grade molybdenum concentrate. Therefore, the scoping study, released in March, suggested the best value would be achieved by producing a rough grade concentrate and leaching and roasting this concentrate to produce molybdenum oxide and ammonium perrhenate (Ivanhoe Mines Ltd., 2011, p. 9, 13).

Canada.—Roca Mines Inc. announced molybdenum production of approximately 630 t of molybdenum concentrate at its Max molybdenum mine from August 2009 to August 2010, a 42% decrease compared with the 1,080 t during the same period of the previous year. The Max underground molybdenum mine is near Trout Lake, British Columbia. Roca Mines sells the molybdenum concentrates produced at its Max Mine to a British-based buyer (Roca Mines Inc., 2010).

TCMC announced in August 2009 that the Endako Mine expansion project that was postponed in December 2008, owing to the economic downturn, was approved to resume. In July 2010, TCMC received the approval of TCMC's joint-venture partner, Sojitz Corp., for the mill expansion project. The expansion project included an upgrade of all processing equipment, construction of a new modern mill building, and a new mining plan, which was expected to widen the area being mined. As a result of the mill expansion, annual molybdenum production was expected to be between 6,800 and 7,300 t/yr of molybdenum, of which TCMC 75% share would be between 5,000 and 5,400 t/yr of molybdenum. The mill expansion project was expected to be completed in the fourth quarter of 2011, with additional production ramping up from the Endako Mine during that quarter. The Endako Mine is near Fraser Lake, 161 kilometers (km) northwest of Prince George, British Columbia. The Endako Mine is a fully integrated facility that includes a concentrator and a roasting facility. Production from the Endako Mine is sold primarily under annual supply contracts to customers from the chemical, petroleum catalyst, and chemical fields (Thompson Creek Metals Company, 2011, p. 8, 24, 34–35).

Taseko Mines Ltd. announced that it produced 430 t of molybdenum in 2010, a 50% increase compared with 285 t of molybdenum produced in 2009 at its Gibraltar Mine in south-central British Columbia. According to the company, the production increase was a direct result of the investments in mine and concentrator equipment performed in 2010 (Taseko Mines Ltd., 2011).

Chile.—Corporación Nacional del Cobre de Chile (Codelco), the state-controlled copper and molybdenum producer, announce a 60% increase in net earnings to $1.87 billion in 2010 owing to higher copper and molybdenum prices. Molybdenum production rose to 22,000 t in 2010, a slight increase compared with the 21,500 t produced in 2009. According to the company, its molybdenum production was expected to increase during the next 3 to 5 years, as new ore zones containing more molybdenum were brought into production at its Andina, Chuquicamata, and El Teniente Mines in Chile (Metal-Pages, 2011c).

Antofagasta plc announced that molybdenum production at its Los Pelambres Mine was 8,800 t of molybdenum, a 13% increase compared with 7,800 t of molybdenum produced in 2009. Los Pelambres is in Chile's Coquimbo Region, 240 km northeast of Santiago. According to the company, the plant expansion initiated in mid-2008 was successfully completed, on schedule and on budget, during the first quarter of 2010. The company expected to produce approximately 9,300 t of molybdenum in 2011, based on the plant expansion and a stable molybdenum grade of approximately 0.019% Mo (Antofagasta plc, undated, p. 17, 28).

Molibdenos y Metales S.A. (Molymet) announced that construction of the Molynor Industrial Complex, in the port of Mejillones in northern Chile began in 2008 and was fully operational in January 2010. According to the company, the new plant was expected to have a production capacity of 13,600 t/yr of molybdenum (Molibdenos y Metales S.A., 2011).

China.—China's imports of molybdenum concentrates decreased by 58% in the first 11 months of 2010 compared with imports during the same period of 2009, according to official customs data. China imported 5,464 t of Mo concentrate in the January through November 2010 period, with an average price of $10,909 per metric ton, 15% higher than the average price during the same period in 2009 (Metal-Pages, 2011a). China's exports of MoO_3 (roasted molybdenum concentrate) increased 157% in the first 11 months of 2010, compared with exports during the same period of 2009. China exported 20,413 t of MoO_3, with an average price of $20,202 per metric ton, 37% higher than the average price during the same period in 2009 (Metal-Pages, 2011b).

China's Ministry of Land and Natural Resources announced that molybdenum would be the sixth protected mined mineral added to a list of strategic resources starting in January 2011. Molybdenum will join antimony, gold, rare earths, tin, and tungsten on its list. China was expected to begin restricting the mining and export of molybdenum as of January 2011 (Metal-Pages, 2010a). In December, China's Ministry of Commerce released the first batch of export quotas for molybdenum chemicals (2,400 t), molybdenum fabricated products (2,295 t), and molybdenum primary materials (20,312 t) for 2011. Molybdenum chemicals included ammonium molybdate, other molybdate salts, and molybdenum oxides and hydrates. Molybdenum fabricated products included molybdenum powder, unwrought metal, and scrap. Molybdenum primary materials included roasted and unroasted molybdenum concentrates and ferromolybdenum. The first batch of export quotas were unchanged from the first batch of export quotas released in 2009 (Metal-Pages, 2010b).

Mongolia.—In July, Erdene Resource Development Corp. (Dartmouth, Nova Scotia, Canada) announced its Zuun Mod molybdenum project in southwestern Mongolia was officially registered with the Mongolian Mineral Resource Council, a prerequisite to applying for a mining license. In November and December 2010, the company carried out a drilling program to provide more detailed information on potential areas of high-grade mineralization to be initially developed for mining. According to the company, the data from this drill program was expected to define a more extensive prefeasibility level drill program designed to upgrade inferred resources to measured and indicated resource categories (Erdene Resource Development Corp., 2011, p. 15).

Peru.—The Cerro Verde Mine of FCX is an open pit copper and molybdenum mining complex 16 km southwest of Arequipa. The mine was shut down in the second quarter of 2009 owing to the economic downturn but reopened in September 2009 (Metal-Pages, 2009). In 2010, molybdenum production at Cerro Verde was approximately 3,180 t of molybdenum compared with 910 t of molybdenum in 2009 (Freeport-McMoRan Copper & Gold Inc., 2011a, p. 38).

Outlook

The principal uses for molybdenum were expected to continue to be in chemicals and catalysts and as an additive in steel manufacturing, most importantly alloy and stainless steel. Molybdenum plays a vital role in the energy industry but may become an increasingly essential factor in green technology, where it is used in high-strength steels for automobiles to reduce weight and improve fuel economy and safety. Molybdenum may play a critical role in reducing sulfur in liquid fuels by acting as a cracking agent. Production of diesel fuels having ultra-low-sulfur levels was expected to more than double the amount of molybdenum used in oil refineries. Analysts expected global demand for these types of catalysts to increase by more than 5% annually until 2013. The need for companies to reduce carbon dioxide emissions from coal-fired power stations will require plants to run at higher temperatures, resulting in greater demand for higher grade molybdenum-bearing steels.

In 2009–10, there were significant production cuts at copper and molybdenum producers worldwide, as well as delays and difficulties in sourcing finance, which have delayed many potential projects. Many analysts think that the molybdenum projects that are expected to commence in 2011–12 still have a significant amount of risk. For example, FCX continued construction at its Climax molybdenum mine in 2010 after halting construction in November 2008 at the height of the global financial crisis. FCX had announced a potential restart date for 2012; however, the company has been very wary of committing to a ramp-up date for Climax, owing to the risk of oversupply in the market.

During the past decade, molybdenum consumption has shown a strong annual growth rate, primarily fuelled by rapid increases in China's industrial growth. Molybdenum demand continues to be driven largely by the steel sector. The fall in stainless steel production mainly took place in developed economies. As emerging economies, such as China and India, continue on the path to industrialization, they are expected to need increasing amounts of molybdenum, and this trend is expected to contribute to global demand growth in the coming years (Virga and Horn, 2009). The outlook for the molybdenum market in 2011 appears to be strong. Increasing steel demand, projected through at least 2015, and the potential for a whole new market from green technology were expected to contribute to increased molybdenum consumption.

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TABLE 1

SALIENT MOLYBDENUM STATISTICS[1]

(Metric tons of contained molybdenum)

	2006	2007	2008	2009	2010
United States:					
Concentrate:					
Production	59,800	57,000	55,900	47,800	59,400
Shipments	60,100	57,100	57,800	63,700	59,400
Reported consumption[2]	44,400	43,900	44,500	W	W
Imports for consumption	10,900	12,400	10,200	7,520	12,900
Stocks, December 31:					
Concentrate, mine and plant	2,120	2,630	1,690	2,550 [r]	2,200
Product producers[3]	3,210	3,140	3,680	3,660	W
Consumers	1,660	1,870	1,620	1,540 [r]	1,630
Total	6,990	7,640	6,990	7,670	3,820
Primary products:					
Production	78,000	72,800	72,900	59,900	68,600
Shipments	51,000	48,700	51,300	43,300	51,100
Reported consumption	19,000	21,000	21,100	17,700 [r]	19,200
World, mine production	186,000	212,000 [r]	218,000	221,000	242,000 [e]

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Molybdenum concentrates roasted to make molybdenum oxide.

[3] Includes ammonium, calcium, and sodium molybdate; briquets; ferromolybdenum; molybdenum hexacarbonyl; molybdenum metal; molybdenum pentachloride; molybdic acid; pellets; phosphomolybdic disulfide; and technical and purified molybdic oxide.

TABLE 2

PRODUCTION, SHIPMENTS, AND STOCKS OF MOLYBDENUM PRODUCTS IN THE UNITED STATES[1]

(Metric tons of contained Mo)

	Metal powder		Other[2]		Total	
	2009	2010	2009	2010	2009	2010
Received from other producers	--	--	W	W	W	W
Gross production during year	(3)	(3)	(3)	(3)	59,900	68,600
Molybdenum products used to make other products	W	W	W	W	W	W
Net production	(3)	(3)	(3)	(3)	33,700 [r]	42,100
Shipments	(3)	(3)	(3)	(3)	43,300	51,100
Producer stocks, December 31	W	W	W	W	3,660	W

[r] Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes ammonium, calcium, and sodium molybdate; ferromolybdenum; molybdenum disulfide; molybdenum hexacarbonyl; molybdenum metal; molybdenum pentachloride; molybdic acid; molybdic oxides; pellets; and phosphomolybdic acid.

[3] Withheld to avoid disclosing company proprietary data; included in "Total."

TABLE 3
U.S. REPORTED CONSUMPTION, BY END USES, AND CONSUMER STOCKS OF MOLYBDENUM MATERIALS[1]

(Kilograms of contained Mo)

End use	Molybdic oxides	Ferromolybdenum[2]	Ammonium and sodium molybdate	Molybdenum scrap	Other	Total
2009:						
Steel:						
Carbon	427,000	297,000	--	--	W	724,000
High-strength low-alloy	W	117,000	--	--	--	117,000
Stainless and heat-resisting	2,030,000	768,000	--	(5)	90,900	2,890,000
Full alloy	3,230,000	2,500,000	--	--	W	5,730,000
Tool	382,000 [r]	W	--	(5)	--	382,000 [r]
Total	6,070,000 [r]	3,680,000	--	--	90,900	9,840,000 [r]
Cast irons (gray, malleable, ductile iron)	W	314,000	--	--	W	314,000
Superalloys	483,000	W	--	(5) [r]	1,010,000	1,490,000 [r]
Alloys (other than steels, cast irons, superalloys):						
Welding materials (structural and hard-facing)	--	43,300 [r]	--	--	3,920 [r]	47,200 [r]
Other alloys	1,020	41,700 [r]	--	--	W	42,700 [r]
Mill products made from metal powder[3]	W	--	--	--	W	W
Cemented carbides and related products[4]	--	--	--	--	77 [r]	77 [r]
Chemical and ceramic uses:						
Pigments	W	--	(5)	--	--	W
Catalysts	950,000	--	(5)	--	W	950,000
Other	--	--	--	--	W	W
Miscellaneous and unspecified uses:						
Lubricants	--	--	--	--	271,000	271,000
Other	662,000 [r]	90,900 [r]	(5)	--	4,020,000 [r]	4,770,000 [r]
Grand total	8,170,000 [r]	4,170,000	--	--	5,390,000 [r]	17,700,000 [r]
Stocks, December 31	318,000 [r]	327,000 [r]	1,960	(6)	(6)	1,540,000 [r]
2010:						
Steel:						
Carbon	426,000	281,000	--	--	W	707,000
High-strength low-alloy	682,000	117,000	--	--	--	800,000
Stainless and heat-resisting	2,160,000	721,000	--	(5)	93,900	2,980,000
Full alloy	3,410,000	3,000,000	--	--	W	6,410,000
Tool	551,000	W	--	(5)	--	551,000
Total	7,230,000	4,120,000	--	--	93,900	11,400,000
Cast irons (gray, malleable, ductile iron)	W	334,000	--	--	W	334,000
Superalloys	517,000	W	--	(5)	1,240,000	1,760,000
Alloys (other than steels, cast irons, superalloys):						
Welding materials (structural and hard-facing)	--	48,300	--	--	W	48,300
Other alloys	1,560	73,000	--	--	W	74,500
Mill products made from metal powder[3]	W	--	--	--	W	W
Cemented carbides and related products[4]	--	--	--	--	78	78
Chemical and ceramic uses:						
Pigments	W	--	7,870	--	--	7,870
Catalysts	945,000	--	(5)	--	W	945,000
Other	--	--	--	--	3,030	3,030
Miscellaneous and unspecified uses:						
Lubricants	--	--	--	--	237,000	237,000
Other	54,300	89,300	(5)	--	4,180,000	4,320,000
Grand total	8,750,000	4,670,000	7,870	--	5,750,000	19,200,000
Stocks, December 31	346,000	347,000	3,850	(6)	(6)	1,620,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Other" of the "Miscellaneous and unspecified uses" category. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes calcium molybdate.

[3] Includes ingot, wire, rod, and sheet.

TABLE 3—Continued

U.S. REPORTED CONSUMPTION, BY END USES, AND CONSUMER STOCKS OF MOLYBDENUM MATERIALS[1]

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[4] Includes construction, mining, oil and gas, and metal working machinery.

[5] Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified uses: Other" of the "Other" category.

[6] Withheld to avoid disclosing company proprietary data; included in "Total."

TABLE 4
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY[1]

Product and country	HTS[2] code	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Oxides and hydroxides, gross weight:[3]	2825.70.0000				
Austria		718	$10,400	432	$9,560
Brazil		318	5,280	184	4,010
Canada		1,760	23,500	2,760	32,600
China		2,060	29,900	551	10,200
Germany		297	5,050	189	3,670
India		484	6,730	280	5,550
Japan		3,050	46,000	1,190	23,600
Netherlands		526	9,200	134	2,630
Turkey		74	1,400	60	1,260
United Kingdom		150	2,210	117	2,520
Other (16 countries)		1,140 r	19,500 r	150	3,640
Total		10,600	159,000	6,040	99,300
Molybdates, all, gross weight:[4]	2841.70.0000				
Australia		20	387	36	673
Canada		257	2,690	707	10,500
Korea, Republic of		17	266	48	375
Netherlands		411	6,370	573	7,760
United Kingdom		25	519	65	1,150
Other (28 countries)		774 r	7,740 r	250	5,730
Total		1,500	18,000	1,680	26,200
Ferromolybdenum, contained weight:[4, 5]	7202.70.0000				
Argentina		13	353	13	507
Canada		581	16,100	677	22,300
India		65	1,550	37	1,150
Mexico		55	1,670	13	525
Netherlands		24	809	196	7,070
Other (14 countries)		86 r	1,970 r	41	1,580
Total		827	22,400	978	33,100
Molybdenum, other, gross weight:[3, 6]	Various[7]				
Austria		6	374	159	10,500
Canada		84	3,090	97	4,240
Germany		137	6,280	85	4,130
Israel		63	4,950	93	7,290
Japan		363	31,800	299	29,800
Korea, Republic of		208	23,300	504	39,900
Mexico		73	4,840	110	7,380
Netherlands		1	132	123	1,820
Taiwan		76	6,630	161	11,700
United Kingdom		294	6,800	600	14,000
Other (47 countries)		477 r	23,700 r	303	22,500
Total		1,790	112,000	2,540	153,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule (HTS) of the United States.

[3] Presentation of annual data is based on the quantities (gross weight) of the 10 leading countries in 2010.

[4] Presentation of annual data is based on the quantities (gross weight) of the five leading countries in 2010.

[5] Ferromolybdenum contains about 60% to 65% molybdenum.

[6] Includes powder, unwrought, waste and scrap, wire, wrought, and other.

[7] Includes HTS codes 8102.10.0000, 8102.94.0000, 8102.95.0000, 8102.96.0000, 8102.97.0000, and 8102.99.0000.

Source: U.S. Census Bureau.

TABLE 5
U.S. EXPORTS OF MOLYBDENUM ORE AND CONCENTRATES (INCLUDING ROASTED AND OTHER CONCENTRATES), BY COUNTRY[1, 2]

Country	2009 Quantity (metric tons of contained Mo)	2009 Value (thousands)	2010 Quantity (metric tons of contained Mo)	2010 Value (thousands)
Belgium	7,060	$165,000	9,610	$251,000
Canada	1,070	26,600	1,150	30,100
China	6,680	145,000	5,280	165,000
India	144	2,290	924	30,500
Japan	912	23,100	2,630	82,600
Korea, Republic of	884	19,900	805	26,500
Mexico	2,870	20,300	5,040	38,500
Netherlands	6,510	153,000	8,210	231,000
South Africa	431	6,340	520	10,100
United Kingdom	2,440	61,100	5,000	148,000
Other (23 countries)	591 [r]	7,520 [r]	1,410	42,400
Total	29,600	631,000	40,600	1,050,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Presentation of annual data is based on the quantities (gross weight) of the 10 leading countries in 2010.

Source: U.S. Census Bureau.

TABLE 6
U.S. EXPORTS OF MOLYBDENUM PRODUCTS[1]

Item	HTS[2] code	2009 Gross weight (metric tons)	2009 Contained Mo (metric tons)	2009 Value (thousands)	2010 Gross weight (metric tons)	2010 Contained Mo (metric tons)	2010 Value (thousands)
Molybdenum ore and concentrates, roasted	2613.10.0000	18,200	18,000	$397,000 [r]	18,800	18,800	$574,000
Molybdenum ore and concentrates, other	2613.90.0000	11,600	11,600	238,000	21,800	21,800	484,000
Molybdenum chemicals:							
Oxides and hydroxides	2825.70.0000	10,600	NA	159,000	6,040	NA	99,300
Molybdates, all	2841.70.0000	1,500	NA	18,000	1,680	NA	26,200
Ferromolybdenum	7202.70.0000	1,200	827	22,400	1,430	978	33,100
Molybdenum powders	8102.10.0000	592	NA	21,100	509	NA	20,900
Molybdenum unwrought, bars and rods	8102.94.0000	25	NA	1,300	273	NA	11,300
Molybdenum waste and scrap	8102.97.0000	373	NA	7,010	707	NA	12,400
Molybdenum wire	8102.96.0000	155	NA	12,000	175	NA	15,200
Molybdenum, other	Various[3]	641	NA	70,400	872	NA	93,500
Total		44,900	NA	946,000	52,300	NA	1,370,000

[r] Revised. NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule (HTS) of the United States.

[3] Includes HTS codes 8102.95.0000 and 8102.99.0000.

Source: U.S. Census Bureau.

TABLE 7

U.S. IMPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY[1]

		2009		2010	
Product and country	HTS[2] code	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Oxides and hydroxides, gross weight:[3]	2825.70.0000				
Chile		148	$2,360	378	$9,510
China		20	605	16	337
Japan		23	148	2	18
Mexico		--	--	92	1,760
Uzbekistan		--	--	20	529
Other (3 countries)		18	220	(4)	3
Total		209	3,330	508	12,200
Molybdates, all, contained weight:[3]	Various[5]				
Belgium		4	587	5	771
Chile		434	14,800	468	16,000
China		198	4,270	400	11,800
Germany		--	--	39	896
Japan		17	663	15	549
Other (4 countries)		4	148	1	110
Total		657	20,500	928	30,100
Molybdenum orange, gross weight:[3]	3206.20.0020				
Canada		227	1,960	247	2,220
Colombia		12	64	10	49
Germany		--	--	6	29
Mexico		25	134	50	293
United Kingdom		--	--	30	78
Other (5 countries)		5	18	7	56
Total		269	2,170	350	2,730
Ferromolybdenum, contained weight:[3, 6]	7202.70.0000				
Belgium		21	571	89	3,290
Canada		87	2,790	348	14,300
Chile		1,730	41,200	2,520	89,800
Korea, Republic of		--	--	99	3,740
United Kingdom		72	2,140	340	11,900
Other (11 countries)		115	3,400	169	6,560
Total		2,030	50,100	3,560	130,000
Other, gross weight:[7]	Various[8]				
Austria		387	18,800	334	23,200
Canada		5	526	85	3,250
China		408	15,700	1,070	43,800
Germany		59	2,530	114	6,040
Hong Kong		9	424	41	1,770
Japan		24	1,460	59	2,390
Mexico		(4)	25	25	111
Poland		--	--	40	1,680
Russia		12	1,350	28	3,130
Taiwan		(4)	42	18	697
Other (20 countries)		66	2,110	29	1,780
Total		970	43,000	1,840	87,800

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Presentation of annual data based on the quantities (gross weight) of the five leading countries in 2010.

[4] Less than ½ unit.

[5] Includes HTS codes 2841.70.1000 and 2841.70.5000.

[6] Ferromolybdenum contains about 60% to 65% molybdenum.

[7] Presentation of annual data based on the quantities (gross weight) of the 10 leading countries in 2010.

TABLE 7—Continued
U.S. IMPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY[1]

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[8] Includes HTS codes 8102.10.0000, 8102.94.0000, 8102.95.3000, 8102.95.6000, 8102.96.0000, 8102.97.0000, and 8102.99.0000.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS OF MOLYBDENUM ORE AND CONCENTRATES (INCLUDING ROASTED AND OTHER CONCENTRATES), BY COUNTRY[1]

	2009		2010	
Country	Quantity (metric tons of contained Mo)	Value (thousands)	Quantity (metric tons of contained Mo)	Value (thousands)
Belgium	--	--	25	$782
Canada	2,000	$45,700	1,620	51,300
Chile	1,910	54,100	3,000	99,200
China	--	--	(2)	3
Germany	--	--	25	935
Mexico	1,910	17,000	4,600	53,500
Peru	1,690	32,900	3,680	108,000
Total	7,520	150,000	12,900	314,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF MOLYBDENUM PRODUCTS[1]

		2009			2010		
Item	HTS[2] code	Gross weight (metric tons)	Contained Mo (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained Mo (metric tons)	Value (thousands)
Molybdenum ore and concentrates, roasted	2613.10.0000	7,780	4,800	$94,800	10,300	6,340	$111,569
Molybdenum ore and concentrates, other	2613.90.0000	5,590	2,720	54,900	13,500	6,610	202,102
Molybdenum chemicals:							
Oxides and hydroxides	2825.70.0000	209	NA	3,330	508	NA	12,162
Molybdates, all	Various[3]	1,170	657	20,500	1,650	928	30,129
Molybdenum orange	3206.20.0020	269	NA	2,170	349	NA	2,729
Ferromolybdenum	7202.70.0000	3,040	2,030	50,100	5,330	3,560	129,638
Molybdenum powders	8102.10.0000	60	52	2,870	232	221	10,146
Molybdenum unwrought, bars and rods	8102.94.0000	107	98	2,880	307	301	10,167
Molybdenum waste and scrap	8102.97.0000	482	473	15,300	703	682	26,944
Molybdenum wire	8102.96.0000	15	NA	2,120	19	NA	3,032
Molybdenum, other	Various[4]	306	NA	19,800	582	NA	37,549
Total		19,000	NA	269,000	33,500	NA	576,168

NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule (HTS) of the United States.

[3] Includes HTS codes 2841.70.1000 and 2841.70.5000.

[4] Includes HTS codes 8102.95.3000, 8102.95.6000, and 8102.99.0000.

Source: U.S. Census Bureau.

TABLE 10
MOLYBDENUM-PRODUCING MINES IN THE UNITED STATES IN 2010

State and mine	County	Operator	Source of molybdenum
Arizona:			
Bagdad	Yavapai	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore, concentrated.
Mineral Park	Mohave	Mercator Minerals Ltd.	Do.
Sierrita	Pima	Freeport-McMoRan Copper & Gold Inc.	Do.
Colorado, Henderson	Clear Creek	do.	Molybdenum ore, concentrated.
Idaho, Thompson Creek	Custer	Thompson Creek Metals Co. Inc.	Do.
Montana, Continental Pit	Silver Bow	Montana Resources	Copper-molybdenum ore, concentrated.
Nevada:			
Ashdown	Humboldt	Win-Eldrich Mines Ltd.	Molybdenum ore, concentrated.
Robinson	White Pine	Quadra Mining Ltd.	Copper-molybdenum ore, concentrated.
New Mexico, Questa	Taos	Chevron Mining	Molybdenum ore, concentrated.
Utah, Bingham Canyon	Salt Lake	Kennecott Utah Copper Corp.[1]	Copper-molybdenum ore, concentrated.

Do., do. Ditto.

[1] Wholly owned subsidiary of Rio Tinto plc.

TABLE 11
MOLYBDENUM: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of contained molybdenum)

Country[3]	2006	2007	2008	2009	2010[e]
Armenia	3,900	4,080	4,250	4,150	4,150
Canada	7,712 [r]	6,681 [r]	8,602 [r]	8,641 [r]	8,261 [p, 4]
Chile	43,278	44,912	33,687	34,925	37,186 [4]
China[e]	43,900	66,700	81,000	93,500	93,600
Iran[e]	2,500	3,600	3,700 [r]	3,700	3,700
Kazakhstan	250	400	400	380	360
Kyrgyzstan[e]	250	250	250	250	250
Mexico	2,519	6,159	7,812	7,800	10,853 [4]
Mongolia	1,404	1,978	1,899 [r]	3,000	2,500
Peru	17,209	16,737	16,721	12,295	16,963 [4]
Russia[e]	3,100	3,300	3,600	3,800	3,800
United States	59,800	57,000	55,900	47,800	59,400 [4]
Uzbekistan[e]	600	600	500	550	550
Total	186,000	212,000 [r]	218,000	221,000	242,000

[e] Estimated. [p] Preliminary. [r] Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 16, 2011.

[3] In addition to the countries listed, North Korea, Romania, and Turkey are thought to produce molybdenum, but output is not reported quantitatively, and available general information is inadequate to make reliable estimates of output levels.

[4] Reported figure.

NICKEL

By Peter H. Kuck

Domestic survey data and tables were prepared by Lisa D. Miller, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

The global recession of 2008–09 led to a dramatic decrease in world nickel mine production. At yearend 2010, several nickel mining companies were still struggling financially despite increased demand for the metal. World mine production bottomed out at 1.41 million metric tons (Mt) of contained nickel in 2009 but increased by almost 15% to 1.62 Mt in 2010 as the global economy improved and prices rose. The London Metal Exchange Ltd. (LME) monthly cash mean for nickel metal slowly recovered in the first half of 2010 and, despite the significant stock buildup in late 2009, ended 2010 at $24,107 per metric ton. Substantial imports of nickel by Chinese consumers and speculative buying by hedge funds helped support the price recovery. Stocks of nickel metal in LME-sanctioned warehouses reached an alltime high of 165,870 metric tons (t) at the end of January 2010. At yearend 2010, LME stocks stood at 136,890 t, down by 14% from 158,424 t at yearend 2009.

The 2008–09 global recession affected almost every sector of the nickel market. Primary nickel usage, however, started to recover in early 2010 as demand for stainless steel rose. Stainless steel continued to account for more than 60% of global primary nickel consumption (Nickel Institute, 2011). In 2010, world production of stainless steel reached an alltime high of 31.1 Mt (International Stainless Steel Forum, 2012). China was the leading producer of austenitic stainless steel, accounting for about 38% of world output, and also the leading consumer of primary nickel. The European Union (EU) was the second ranked producer of stainless steel. In 2010, China produced more austenitic stainless steel than the United States and all of the countries in the European Union combined. The year-on-year growth rate for global stainless steel use declined by 5.7% (revised) in 2009, but then recovered to 23.2% in 2010. On a global basis, nonferrous alloys accounted for about 12% of primary nickel use, followed by electroplating and other surface finishing, with 11%. Another 10% was used to produce alloy steels other than stainless (International Nickel Study Group, 2011b, p. A1–A12; Vale S.A., 2011c, p. 3–7).

Reported nickel consumption (primary plus secondary) in the United States increased by 23% compared with that of 2009. U.S. apparent consumption of primary nickel was 113,000 t, or about 8% of world consumption. Stainless steel comprised only 46% of U.S. primary consumption, a relatively low percentage compared with similar economically developed countries. The low percentage for the United States was a reflection of the large number of specialty metal industries and a readily available supply of stainless steel scrap. U.S. industry reported melting an additional 105,000 t of nickel contained in scrap.

Legislation and Government Programs

In conjunction with the American Recovery and Reinvestment Act of 2009 (Public Law 111–5), the U.S. Department of Energy (DOE) funded a variety of programs designed to encourage more rapid development of renewable energy sources. Specific research and development projects included domestic manufacturing of advanced batteries; development of improved stationary and portable fuel cell power systems; development of commercial-scale biorefineries; improved design of molten-salt storage facilities at powerplants that concentrate solar energy; design and evaluation of parabolic troughs, dishes, and heliostats for solar power stations; and construction of demonstration facilities designed to recover and better utilize geothermal energy (U.S. Department of Energy, 2012). All of these expanding subsectors for generating power have the potential to be important users of nickel metal and (or) nickel-bearing alloys.

In the United States, domestic use of renewable energy increased by 21% from 2006 to 2010, and accounted for about 8% of U.S. energy consumption in 2010 (U.S. Energy Information Administration, 2011). In fiscal year 2010, Federal agencies implemented nearly 700 renewable energy initiatives. The Departments of Agriculture, Defense, Energy, and the Interior were responsible for almost 60% of these initiatives. The 679 identified initiatives supported 7 different renewable energy sources—bioenergy, geothermal, hydropower, ocean, solar, waste conversion, and wind (U.S. Government Accountability Office, 2012). Implementation of these technologies has the potential to increase the use of nickel-bearing steels and superalloys.

At the beginning of 2010, the U.S. Mint resumed production of the Jefferson nickel (25% nickel by weight) and the Roosevelt dime (8.33% nickel). The Mint had suspended production of the two coins in April 2009 in response to a slowing economy. The Mint produced a total of 490.6 million Jefferson nickels and 1,119.0 million Roosevelt dimes in 2010, up from 86.64 million nickels and 146.0 million dimes in 2009 (U.S. Mint, undated b).

Because of the popularity and budgetary benefits of both the 50 State Quarters™ Program and the Territorial Program, the U.S. Congress approved the Mint's request to launch a program in 2010 that would promote the Nation's parks and historical sites. As in 2009, minting was limited because of the sluggish economy. The U.S. Mint produced only 347.0 million commemorative quarters in 2010, down from 636.2 million in 2009. Each coin weighed 5.67 grams (g) and contained 8.33% nickel; thus 164 t of nickel was contained in the five commemorative quarters released in 2010 (U.S. Mint, undated a, b).

In 2010, the U.S. Mint produced 80.78 million Native American dollar coins and 321.4 million Presidential dollar coins. Each dollar coin weighed 8.1 g and contained 2.0% nickel, for a total use of 65 t of nickel (U.S. Mint, undated b, c).

Mine Development and Production

Michigan.—Kennecott Eagle Minerals Co. continued to develop its Eagle copper-nickel mine near Big Bay. In January, the Michigan Department of Environmental Quality (MDEQ) formally approved the permits needed to begin construction of the $300 million underground mine, after an administrative law judge ruled in favor of Kennecott at the conclusion of a series of strongly contested cases. Site preparation work began in April, with the mine scheduled to be completed by yearend 2012. Ore would be trucked from the mine to a renovated mill near Champion, where the copper-nickel sulfides would be concentrated. The concentrates would then be railed to Ontario, Canada, for smelting. Renovation of the Humboldt mill was expected to cost about $100 million. In February, the Michigan Department of Natural Resources and Environment (the successor to MDEQ) issued the necessary permits to refurbish and operate the mill (Kennecott Eagle Minerals Co., 2010; 2012; Michigan Department of Environmental Quality, 2010; Pepin, 2010).

Minnesota.—PolyMet Mining Corp. (Vancouver, British Columbia, Canada) was preparing to mine the NorthMet deposit pending approval from the State of Minnesota. In late 2009, the Minnesota Department of Natural Resources released the revised draft environmental impact statement (EIS) for public comment. By yearend 2010, a supplemental draft EIS was in progress to better analyze the environmental impacts of the project and to more clearly demonstrate that the PolyMet project would fully comply with State and Federal environmental standards (PolyMet Mining Corp., 2010a).

The NorthMet deposit, a copper-nickel-platinum group element (PGE) deposit at the western end of the Duluth Complex, was estimated to have 249 Mt of proven and probable reserves averaging 0.29% copper and 0.08% nickel. Ore from the proposed open pit would be shipped to the reconditioned Cliffs Erie mill near Hoyt Lakes, MN, for processing through flotation. The concentrate would be processed at the Erie site in a new hydrometallurgical plant to produce copper cathode, nickel-cobalt hydroxide, and a precious-metals precipitate.

In November 2010, PolyMet agreed to sell $30 million worth of common stock to Glencore International AG (Baar, Switzerland). The $30 million would be used primarily to fund construction of the NorthMet Mine and to modify the Erie processing facility. Glencore made a similar equity investment of $25 million in late 2009 (PolyMet Mining Corp., 2010b; 2011).

Duluth Metals Ltd. (Toronto, Ontario, Canada), Franconia Minerals Corp. (Spokane, WA), and Teck American Inc. (Spokane) continued to actively evaluate disseminated sulfide deposits in the Duluth Complex, with a focus on the Mesaba-Birch Lake-Nokomis area (Minnesota Minerals Coordinating Committee, 2011). In July, Duluth Metals formed a joint venture with Antofagasta Plc (London, United Kingdom) to develop the Nokomis property. Antofagasta would own 40% of the new venture—Twin Metals Minnesota LLC—and would initially provide $130 million to the project (Duluth Metals Ltd., 2011, p. 1–3, 7–11, 16–17; Newby and Moore, 2011).

Byproduct Smelter and Refinery Production.—The United States had no active nickel mines in 2010, although limited quantities of byproduct nickel were recovered at some copper and precious metal refineries. In 2010, Stillwater Mining Co. shipped 525 t of nickel in crystalline sulfate, up from 388 t in 2009. Stillwater mined PGEs in Montana's Beartooth Mountains. Concentrates from the company's two mills (East Boulder and Nye) were trucked to the company's smelting and refining complex at Columbus, MT, where a PGE filter cake and byproduct crystalline nickel sulfate containing minor amounts of cobalt were produced. In December, MMC Norilsk Nickel, Stillwater's majority shareholder, completed the sale of all of its common stock in the company to a broad spectrum of independent investors. The sale was valued at nearly $1 billion and ended Norilsk's 7-year majority ownership in Stillwater (Stillwater Mining Co., 2011, p. 9, 16–18, 23–27, 52–54).

Freeport-McMoRan Copper & Gold Inc. (Phoenix, AZ) produced limited quantities of byproduct nickel carbonate at its El Paso, TX, copper refinery (Freeport-McMoRan Copper & Gold Inc., 2011, p. 26).

No ferronickel was produced in the United States in 2010 from either domestic or imported ores. Almost all U.S. ferronickel exports were either re-exports or material upgraded for special purposes. The steel industry accounted for virtually all the ferronickel consumed in 2010, with more than 97% used in stainless, heat-resistant, or specialty alloy steels.

Secondary Production.—At yearend 2009, Horsehead Holding Corp. (Pittsburgh, PA) acquired The International Metals Reclamation Co. (INMETCO) from Vale Inco Ltd. (Toronto, Canada) for $34 million. INMETCO operated the only secondary smelter in North America dedicated to recycling both chromium and nickel from waste and scrap. The smelter at Ellwood City, PA, produced a remelt alloy that typically averaged 13% chromium and 12% nickel. Stainless steel producers used the remelt alloy as a substitute for ferrochromium and ferronickel. INMETCO was capable of processing a wide range of nickel-bearing wastes including flue dust, grindings, mill scale, and swarf generated during the manufacturing of stainless steel. The smelter also accepted filter cakes, plating solutions, sludges, and spent rechargeable batteries (Horsehead Holding Corp., 2010).

Gulf Chemical & Metallurgical Corp. (Freeport, TX) [owned by Eramet Group (Paris, France)] was one of a limited number of companies worldwide that processed spent catalysts from petroleum refineries. The Freeport facility could treat nickel-molybdenum and cobalt-molybdenum hydrotreating catalysts that had been "poisoned" by nickel and vanadium tied up in porphyrins and other organometallic molecules of crude oil. Gulf Chemical first roasted and leached the catalysts to recover the molybdenum and vanadium. The nickel-and-alumina residue was then converted to a crude, but marketable nickel-cobalt alloy in a direct-current electric arc furnace (EAF) (Gulf Chemical & Metallurgical Corp., undated).

Consumption

Apparent primary nickel consumption in the United States increased by 20% to 113,000 t in 2010 from 93,900 t in 2009. The estimated value of apparent primary nickel consumption was $2.47 billion, up from $1.38 billion in 2009. The sharp increase in the value of primary consumption resulted from a

49% increase in the LME cash price in addition to increased use in the aftermath of the recession. Apparent primary consumption plus reported secondary consumption totaled 218,000 t, up from 174,000 t (revised) in 2009 (table 1).

Stainless Steel and Low-Alloy Steels.—In 2010, stainless steel producers accounted for 46% of reported primary nickel consumption in the United States (table 4) and more than 60% of primary consumption in the world. Production of raw stainless steel and heat-resisting steel in the United States totaled 2.20 Mt in 2010, up by 36% from 1.62 Mt in 2009. Nickel-bearing grades accounted for 1.54 Mt, or 70% of total stainless steel production (American Iron and Steel Institute, 2011a, p. 72–73; b).

North American Stainless (NAS) in Ghent, KY, produced 899,000 t of stainless steel slabs—32% more than that of 2009. NAS was able to maintain its leading position in the U.S. flat products market during the global economic crisis (Acerinox, S.A., 2011, p. 24–25, 178–181).

In December, ThyssenKrupp Steel USA, LLC and ThyssenKrupp Stainless USA, LLC opened the first stage of a $5.0 billion steelmaking and processing complex at Calvert, AL, which included a hot strip mill for processing 3 million metric tons per year (Mt/yr) of carbon steel slab from Brazil and can produce 4.1 Mt/yr of carbon steel end products. The second stage was to include a stainless steel meltshop capable of producing up to 1 Mt/yr of stainless steel slabs. The stainless slabs would be rolled at the new hot strip mill. The startup of the stainless steel meltshop was scheduled for December 2012. The meltshop would have a 160-t capacity EAF, a 180-t capacity argon oxygen decarburization (AOD) converter, and a 1,900-millimeter (72-inch) continuous caster. Of the $5.0 billion, $1.4 billion was being invested in the stainless melting and rolling part of the Calvert complex (ThyssenKrupp AG, 2010; ThyssenKrupp Steel USA, 2010).

Superalloys and Related Nickel-Based Alloys.—Of the primary nickel consumed in the United States, approximately 21% was used to make high-performance superalloys and related nickel-based alloys for the aerospace, electric power, and petrochemical industries. Flat or declining sales to manufacturers of jet aircraft engines and other sectors of the aerospace industry were offset by rising sales to the electrical energy and defense sectors.

Since 2007, U.S. aerospace sales have steadily increased in the military aircraft, space, and missile sectors of the industry. Civil aircraft sales, in contrast, fell from an interim high of $42.9 billion in 2007 to $36.6 billion in 2010 in terms of constant dollars. A number of factors accounted for the decline in civil sales, including a challenging global economy; the high and volatile price of jet fuel, which hurt airline revenues; new environmental regulations; and the reduced availability of aircraft financing. Lower demand for commercial aircraft in the United States and the European Union (EU) was partially offset by substantial exports of aircraft to Asia and the Middle East. Shipments of U.S.-manufactured civil jet transport decreased to 462 in 2010 from 481 (revised) in 2009. On a global basis, Airbus S.A.S. and The Boeing Co., the two leading manufacturers of large jet transport, delivered a total of 972 commercial aircraft in 2010, a slight decrease from the 979 in 2009 (Aerospace Industries Association, 2011, p. 3–7, 9–14; Airbus S.A.S., 2011; Nowlin, 2011).

In May, General Electric Aviation (an operating unit of General Electric Co.) signed a long-term sourcing agreement with Allegheny Technologies Inc. (ATI) to ensure an adequate supply of the nickel-based ATI 718Plus® superalloy, which has a wide variety of applications in jet engines and industrial gas turbines. The improved superalloy provides a nominal 55 °C (100 °F) temperature advantage over the traditional 718 alloy, enabling a jet engine of the same design to operate at a higher temperature. ATI has had a similar long-term sourcing agreement with Rolls-Royce plc (London, United Kingdom) for related alloys since 2009 (Allegheny Technologies Inc., 2010a, b; 2011, p. 5, 10, F3, F25–F26).

Nickel Use in Industrial Gas Turbines.—The use of natural gas for power generation has been increasing in recent years, spurring consumption of nickel for industrial gas turbines (IGT). The U.S. Energy Information Administration (EIA) has projected that the share of U.S. electric power generation from natural gas will rise to an average of 26.0% in 2015 from an average of 22.7% in 2010. ATI718Plus® could play an increasingly important role in the design and manufacturing of advanced turbines (Allegheny Technologies Inc., 2011, p. 15; U.S. Energy Information Administration, 2011, p. 2–4, 37–40, 78–80, 132; 2012).

Similar, high-performance, nickel-based superalloys were already being used in a variety of both gas and steam turbine components. Doncasters Group Ltd. (Burton-Upon-Trent, Staffordshire, United Kingdom) was a leading manufacturer of critical IGT components and assemblies. Doncasters had several subsidiaries in the United States that produced, cast, or machined nickel alloys. Certified Alloy Products Inc. (Long Beach, CA), for example, produced nickel and cobalt vacuum-refined superalloys for use in aerospace engine and IGT components. Doncasters Southern Tool (Oxford, AL) produced a variety of air and vacuum melt investment castings (Doncasters Group Ltd., 2008).

Nickel Use in Geothermal Power Stations.—Nickel-base superalloys and stainless steel play several important roles in geothermal operations. A geothermal powerplant is similar to a conventional steam turbine operation except that the steam is piped directly from a subterranean reservoir and must be cleaned of its suspended solids and dissolved salts before it can be used to spin the turbine. Piping made from a nickel-based superalloy or austenitic stainless steel is frequently used to minimize corrosion from salts in hot geothermal brines.

The U.S. geothermal energy industry continued to make headway in 2010 despite financing and permitting delays. In October, Energy Source LLC (El Centro, CA) began constructing a geothermal powerplant and chemical complex near Calipatria, on the southeastern edge of the Salton Sea in southern California. Phase I of the Hudson Ranch project was scheduled to come online in the spring of 2012. Construction of phase 2 would begin in early 2012. ThyssenKrupp VDM GmbH (Werdohl, Germany) was supplying 12-meter long sections of pipe fabricated from nickel alloy 625, a brine-resistant alloy strengthened by the addition of molybdenum and niobium (Richter, 2010; ThyssenKrupp AG, 2011; Wald, 2011).

In Nevada, Gradient Resources Inc. was preparing to launch the first phase of its Patua greenfield power project in Lyon County, east of Reno. Production well drilling started in 2010 (Chichon, 2012). DOE was evaluating an enhanced geothermal system (EGS)—Desert Peak—near Fernley in the Hot Springs Mountains of neighboring Churchill County. The DOE EGS stimulation well was adjacent to the existing geothermal power station operated by Ormat Technologies Inc. (Reno, NV) (U.S. Department of Energy, 2009, p. 1–14).

Nickel-Based Batteries and Hybrid Electric Vehicles.—U.S. demand for nickel in rechargeable batteries continued to increase. In 2010, most of the newer hybrid electric vehicles (HEVs) on U.S. highways used nickel-metal hydride (NiMH) batteries. Ford Motor Co., Honda Motor Co., Ltd., and Toyota Motor Corp. have all relied on NiMH batteries because of their proven durability, stability, and safety (Voelcker, 2010).

The battery market remained highly competitive and a variety of lithium ion (Li-ion) and lithium phosphate batteries began making inroads against the standard NiMH design. As an example, the Chevrolet Volt, an electric vehicle with extended range, has a Li-ion battery pack with 288 rectangular cells (General Motors Co., 2012). Some of the new proprietary lithium-ion batteries reportedly have four times the energy capacity of equivalent nickel-cadmium batteries and twice that of the newer NiMH products.

The General Electric Co. was converting a steam turbine assembly facility at Schenectady, NY, to a battery manufacturing facility. The $100 million facility was expected to manufacture sodium-metal halide batteries containing nickel chloride as a key component. The advanced battery, designed for data centers and backup power, reportedly can store three times more energy than an equivalent conventional lead-acid battery (Rotman, 2012).

Stocks

On January 1, 2010, stocks in LME warehouses worldwide totaled 158,424 t. LME stocks, which had been slowly building up from an alltime (end-of-month) low of 3,366 t in January 2007, peaked at 165,870 t on January 31, 2010. They then declined to 118,380 t on July 31, before rising to 136,890 t at yearend. Data collected by the International Nickel Study Group (INSG) indicated that, at yearend 2010, world nickel producers [excluding those in Austria, China, Macedonia, Kosovo (listed as Serbia by INSG), and the Ural region of Russia] had an additional 91,300 t of primary nickel stocks. About 70%, or 64,100 t, of the producer stocks was class I material (refined products with a nickel content of 99% or greater), which included, in order of decreasing quantity, electrolytic cathode, briquets, pellets, powder, and rondelles. The remaining 30% was class II material (products with a nickel content of less than 99%), which included ferronickel, oxide sinter, and East Asian utility nickel. All stocks in LME warehouses were class I (International Nickel Study Group, 2011b, p. A1–A2, A7–A8). In comparison, at yearend, U.S. consumer stocks of primary nickel totaled 11,200 t, 30% more than the 8,580 t (revised) held at yearend 2009 (tables 1 and 5).

Prices

Nickel prices trended upward in 2010, driven by the global economic recovery. However, actions by hedge funds, institutional investors, and speculators caused sharp variations in pricing to be superimposed upon the general trend. The January 2010 average cash price for 99.8%-pure metal on the LME was $18,435 per metric ton ($8.362 per pound). A high of $26,023 per ton ($11.804 per pound) was reached in April. Nickel prices weakened slightly at midyear, declined to $19,383 per ton ($8.792 per pound) in June, but then slowly began to rise again. The monthly average for December was $24,107 per ton ($10.935 per pound), about 30% higher than that of January. The average annual LME price was $21,804 per ton ($9.890 per pound)—49% greater than the 2009 average.

World Review

The world's leading producer of nickel ore was Norilsk (Russia), followed by Vale S.A. (Brazil and Canada) and the BHP Billiton Group (Australia and United Kingdom). PT Aneka Tambang Tbk. (Indonesia) was in fourth place, producing large tonnages of direct shipping ore for the Chinese nickel pig iron (NPI) industry. Other major producers were Eramet Group (France), Jinchuan Non-ferrous Metals Corp. (JNMC) (China), and Xstrata plc (Switzerland).

The global recession dampened acquisitions and mergers of nickel producers, with some exceptions. Altona Mining Ltd. (West Perth, Australia) took over management of the shuttered Hautalampi nickel-copper-cobalt mine along with the Kuhmo and Kylylahti copper-nickel projects—all in eastern Finland. Chinese companies continued to acquire mining interests throughout the world and signed offtake agreements or similar financial instruments with the owners of nickel mines in Australia, Canada, and the Philippines.

In 2010, world use of primary nickel was reported to be 1.46 Mt—an alltime high—and was 4% greater than the previous high of 1.40 Mt in 2006 (International Nickel Study Group, 2012, p. A–1 and A–5). A few nickel producers continued to operate at full capacity, but others cut back production and slowed development or postponed projects. Some producers were concerned about a possible double-dip recession and its effect on mid-term nickel prices. A prolonged labor dispute crippled Vale Nickel's mining and smelting operations in eastern Canada and contributed to lower output. Global demand continued to be buoyed by upward trending apparent consumption in China, which had risen to 575,000 t in 2010 from 66,800 t in 2000. The Chinese stainless steel industry continued to expand and used a record-high 425,000 t of primary nickel in 2010, a 25% increase from the amount consumed in 2009. The Chinese stainless steel industry overtook that of the EU in 2009 to become the leading consumer of primary nickel. The steel industry of the EU consumed 214,000 t of primary nickel in 2010, while the Japanese steel industry was in third place with 90,000 t (Eramet Group, 2012, p. 31–35).

Production of raw stainless steel (excluding production in China, the Commonwealth of Independent States, and Eastern

Europe) had increased at a compound annual growth rate of 5.1% since 1950. That rate included the recession period when production dropped from 20.8 Mt in 2007 to 16.1 Mt in 2009 (Vale S.A., 2011c, p. 4). According to the International Stainless Steel Forum (2012), stainless steel production for the entire world rose to 31.1 Mt in 2010 from 24.9 Mt in 2009 and 25.9 Mt in 2008.

Australia.—Australia was the fourth ranked nickel-producing country in the world. Seven companies in Western Australia reported producing salable nickel in 2010. One other company, plus two of the seven, trucked sulfide ore to BHP Billiton's concentrator at Kambalda for further processing [Department of Mines and Petroleum (Western Australia), 2011, p. 35–37].

Laterite Operations.—The Yabulu refinery of Queensland Nickel Pty. Ltd. processed laterite ores purchased from third party mines in Indonesia, New Caledonia, and the Philippines. In 2010, Yabulu produced about 29,400 t of nickel in compacts (a product similar to rondelles) averaging 98.5% nickel or greater (Queensland Nickel Pty. Ltd., 2011).

In February, First Quantum Minerals Ltd. purchased the idled Ravensthorpe complex in Western Australia from BHP Billiton. First Quantum thought that if $150 million worth of modifications were made to the front end of the complex, the plant would be capable of producing between 28,000 and 39,000 t/yr of nickel metal. Recommissioning was scheduled for late 2011 (First Quantum Minerals Ltd., 2010a; b, p. 9–12).

The Murrin Murrin joint venture near Leonora, Western Australia, used sulfuric acid to leach nickel and cobalt from lateritic ores in high temperature, high-pressure autoclaves. The laterite mining and processing operation produced 28,378 t of nickel, down by 14% from the 32,977 t produced in 2009. Murrin Murrin was jointly owned by Minara Resources Ltd. (60% interest) and Glenmurrin Pty. Ltd. (a subsidiary of Glencore) (40%). Nickel production declined in 2010, owing to a pipeline failure in the autoclave circuit in May and a triennial statutory shutdown in October. In 2010, Murrin Murrin mined 3.2 Mt (dry) of ore grading 1.29% nickel and 0.093% cobalt. In September, the company began developing the Murrin Murrin East orebody. In late 2010, Minara also added a sixth reduction autoclave and a second flash vessel to the refinery's nickel circuit to make the operation more flexible (Minara Resources Ltd., 2011, p. 2, 4, 6, 16, 19).

Sulfide Operations.—*Tasmania.*—The Avebury Mine [Minmetals Australia Pty. Ltd. (Melbourne, Victoria)] remained on care-and-maintenance status throughout 2010. Minmetals acquired Avebury from OZ Minerals Ltd. as part of a $1.4 billion buyout in late 2009.

Western Australia.—In 2010, BHP Billiton's Nickel West produced 43,600 t of metal briquettes and powder at Kwinana from matte made at Kalgoorlie. Kwinana also produced several intermediate products, including cobalt-nickel sulfide, copper sulfide, and ammonium sulfate. The Kalgoorlie smelter produced about 61,700 t of nickel in finished matte for export. The matte typically contained 68% nickel. About one-third of the concentrate came from the Mount Keith Mine in the Northern Goldfields region. The remaining two-thirds came from Leinster and third party mines at Kambalda.

Nickel West continued to expand its Mount Keith operation and was reevaluating the undeveloped Yakabindie deposit, 25 kilometers (km) south of Mount Keith. In September 2009, contractors began constructing a magnesium oxide flotation circuit at Mount Keith designed to separate the talc from the pentlandite concentrate, producing a marketable coproduct. About 25% of the remaining nickel ore reserves at Mount Keith contain excessive levels of talc. The talc circuit was scheduled to come onstream in 2012. The Mount Keith operation also was concentrating high-grade ore from the company's new Cliffs underground mine, 12 km to the south (BHP Billiton, 2011, p. 40–41, 57, 87).

In 2009, Norilsk Nickel International temporarily suspended production at all of its mining operations in Western Australia owing to the unfavorable global economic situation. The Lake Johnston sulfide flotation plant and all five of Norilsk's mines in the Leinster-Kalgoorlie region were still on care-and-maintenance status at the end of 2010. The idled mines—all underground—included the Black Swan-Silver Swan complex, the Emily Ann, the Maggie Hays, and Waterloo (OJSC MMC Norilsk Nickel, 2011, p. 52–55, 62).

Western Areas NL mined 266,000 t of sulfide ore grading 3.9% nickel and containing 10,479 t of recoverable nickel at its Flying Fox underground mine at Forrestania in fiscal year ending June 30, 2010. In June, Western Areas commissioned the Tim King open pit at its new Spotted Quoll Mine, also in the Forrestania District. Ore from the Tim King was grading 6.3% nickel. The first sulfide concentrate from the company's newly upgraded Cosmic Boy mill was shipped to the Jinchuan Non-ferrous Metals Group in China for downstream processing as part of an offtake agreement. Development of the underground portion of the Spotted Quoll ore complex was scheduled to begin in March 2011. The new underground workings would be reached from a decline being constructed in the pit wall of the Tim King [Department of Mines and Petroleum (Western Australia), 2011, p. 35–36; Western Areas NL, 2010, p. 3–14].

Brazil.—Four companies mined nickel ore in Brazil in 2010—Anglo American Brasil Ltda., Cia. de Nickel do Brasil, Grupo Votorantim, and Mirabela Nickel Ltd. Two major mining and metallurgical processing complexes were essentially completed—the Barro Alto ferronickel smelter and refinery in Goias State (Anglo American plc) and the Onça Puma mining and ferronickel complex in Para State (Vale Nickel). In March, however, Votorantim Metais Niquel S.A. (a subsidiary of Grupo Votorantim) reportedly suspended work on its new Niquelandia ferronickel smelter in Goias State.

Votorantim Metais was the leading producer of electrolytic nickel in Latin America and operated a nickel-cobalt refinery in Sao Miguel Paulista, Sao Paulo State, capable of producing 23,000 t/yr of electrolytic nickel and 1,420 t/yr of electrolytic cobalt. The Sao Miguel Paulista refinery used intermediate nickel carbonate from the company's operation in Niquelandia for feed. The electrolytic nickel was 99.9% pure and was registered on the LME. The sulfide smelter of Votorantim Metais at Fortaleza de Minas, Minas Gerais State, produced 14,308 t of nickel in matte in 2010, primarily for export to Finland, up from

8,518 t in 2009. The matte typically assays 50% to 55% nickel, 7% to 12% copper, and 0.14% to 1% cobalt (Da Silva, 2012; International Nickel Study Group, 2011b, p. B–10; Votorantim Metais, 2008).

In October, Vale Nickel began ramping up production at its new Onça Puma complex in the Ourilandia do Norte District, Para State. The Onça and Puma Mines have a combined 82.7 Mt of saprolitic reserves averaging 1.73% nickel. Ores from the two open pits were being blended in coal-fired rotary kilns and then charged into electric furnaces to produce ferronickel. Onça Puma was expected to reach its full production capacity of 53,000 t/yr of nickel-in-ferronickel in late 2012. The entire project was expected to cost $2.84 billion (Hatch Ltd., 2011, p. 22; Vale S.A., 2011b).

In December 2010, Anglo American plc began commissioning its Barro Alto smelter in Goias State and poured the first molten ferronickel in March 2011. When fully operational in late 2012, Barro Alto would be capable of producing 41,000 t/yr of nickel-in-ferronickel. Capital expenditures for Barro Alto totaled $1.9 billion. Saprolitic ore from the adjoining Barro Alto Mine was already being processed at Anglo's existing Codemin ferronickel plant, 170 km away in Niquelandia. In 2010, the Codemin plant produced 8,465 t of nickel-in-ferronickel. The Codemin open pit had 7.7 Mt of proven and probable lateritic reserves averaging 1.28% nickel. The Barro Alto open pit had 47.5 Mt of proven and probable lateritic reserves grading 1.68% nickel. The ferronickel plant had two 185-meter-long rotary kilns for calcining the raw ore and two 83-megawatt (MW) EAFs for final smelting (Anglo American plc, 2011a; 2011b, p. 59–68).

In August 2009, Mirabela Nickel Ltd. (Perth, Australia) began mining nickel and copper sulfides at its Santa Rita project near Ipiau, Bahia State. The crushing, grinding, and concentrating complex was commissioned in October 2009. After ramp up was completed in 2010, Santa Rita had the capacity to produce 27,000 t/yr of nickel in sulfide concentrate. Mirabela was shipping 50% of the concentrate produced at Santa Rita to Norilsk Nickel's Harjavalta smelter in Finland. The remaining 50% was trucked 1,350 km to Votorantim's Fortaleza smelter in Minas Gerais. Mirabela sold 9,956 t of nickel in concentrate to Votorantim Metais in 2010 as part of its offtake agreement. Santa Rita reportedly had 16.7 Mt of proven reserves averaging 0.57% nickel and 143 Mt of probable reserves grading 0.52% nickel (Mirabela Nickel Ltd., 2011, p. 7–10).

Canada.—Four Provinces had active nickel mines in 2010—Manitoba, Newfoundland and Labrador, Ontario, and Quebec. In addition, companies were evaluating a variety of nickel deposits in all but two of the remaining nine provinces or territories.

British Columbia.—In 2007, exploration companies began discovering disseminated awaruite, a naturally occurring nickel-iron alloy, in the ultramafic complexes of northern British Columbia. Nickel has traditionally been extracted from three ore types—sulfide ores containing pentlandite and chalcopyrite; lateritic ores rich in limonite; or lateritic ores rich in saprolitic mineralization such as garnierite. First Point Minerals Corp. (Vancouver, British Columbia), however, decided to evaluate the awaruite potential of the Decar, Klow, Wale, and four other properties in the province. The Decar project, on the west bank of the Stuart River, is a joint venture with Cliffs Natural Resources Inc. (Cleveland, OH). Composite samples from the Decar property averaged 0.14% nickel in alloy. Preliminary metallurgy work on samples from the Decar property produced a ferronickel concentrate grading 2.6% nickel, 2.2% chromite, and 52% iron as magnetite. About 80% of the nickel iron-alloy was recoverable (First Point Minerals Corp., 2011).

Manitoba.—Vale Nickel's operations at Thompson produced 29,800 t of refined nickel in 2010 from ores extracted from the Birchtree and Thompson Mines. The Thompson Mine produced 1.33 Mt of ore grading 1.83% nickel; the Birchtree, 832,000 t grading 1.41% nickel (Vale S.A., 2011a, p. 38–39).

In November 2009, Crowflight Minerals Inc. (renamed CaNickel Mining Ltd. in 2011) suspended mining and milling for 3 months at its new Bucko Lake Mine near Wabowden. The action was taken so that key improvements and upgrades could be made to the underground part of the operation. The company resumed milling and shipments of concentrate in March 2010, but suspended operations in October until spring 2011 (CaNickel Mining Ltd., 2012, p. 4–9).

Newfoundland and Labrador.—The Ovoid Mine at Vale Nickel's Voisey's Bay operation extracted 1,510,000 t of ore grading 3.20% nickel and 2.44% copper. The mined tonnage yielded 42,300 t of finished nickel, up from 39,700 t in 2009, but down from a record 77,500 t in 2008. A prolonged labor dispute that began in August 2009 and continued until January 2011 was responsible for the substantial drop in production of finished nickel. Vale has been constructing a hydrometallurgical processing plant at Long Harbour, Newfoundland, since April 2009. The Long Harbour plant was scheduled to begin operation in 2013 using concentrates from Voisey's Bay as feed. In 2010, Vale Nickel shipped the high-grade nickel concentrate produced at Voisey's Bay to Sudbury and Thompson for smelting and downstream processing (Vale S.A., 2011a, p. 38–39; 2012).

Ontario.—Sudbury has been the leading nickel-producing district in Canada since the discovery of the first ore body in 1883. Vale Inco's Ontario Division operated at well below capacity for most of 2010, owing to a prolonged strike that began in July 2009 and lasted until July 2010. The strike was the longest in the history of the Sudbury-Port Colborne operation (Kosich, 2010). As a result, the division produced only 22,400 t of finished nickel in 2010 from its own ores, down from 43,600 t in 2009 and 85,300 t in 2008. The division had seven mines operating in 2010. Part of the refined nickel was recovered from intermediate nickel oxide at the division's Clydach refinery in the United Kingdom. Despite the ongoing strike, Vale Inco continued to develop its new $450 million Totten Mine. The partially completed mine produced 16,000 t of ore grading 2.54% copper and 1.74% nickel in 2010 (Vale S.A., 2011a, p. 38–39).

Xstrata, Sudbury's other principal producer, mined 1,216,000 t of ore with an average grade of 1.40% nickel and 2.81% copper (Xstrata plc, 2011b, p. 7–8). Xstrata's smelter at Falconbridge produced 73,667 t of nickel in matte, which was shipped to the company's Nikkelverk operations in Norway for refining. On April 1, Xstrata officially commissioned its new Nickel Rim South Mine. The main shaft is about 9 km northeast of Xstrata's smelter at Falconbridge. The Nickel Rim South ore body, which was discovered in 2001 and cost $809 million to develop, reached its nameplate capacity of 1.25 Mt/yr of ore in October, 6 months ahead of schedule (Xstrata plc, 2011a, p. 10, 34–35, 83, 98).

In May, FNX Mining Co. Inc. merged with Quadra Mining Ltd. to form Quadra FNX Mining Ltd. The new company operated the Levack/Morrison, McCreedy West, and Podolsky Mines—within 35 km of Sudbury—and retained the mineral rights to the Kirkwood and Victoria properties (Quadra FNX Mining Ltd., 2011, p. 7–8, 17–32).

In June 2009, Xstrata suspended mining indefinitely at its Montcalm Mine near Timmins after a geotechnical review revealed that subterranean rock failure and subsequent movements had structurally damaged the mine. The Montcalm Mine was idle in 2010 owing to safety concerns and the need to fully assess the situation (Xstrata plc, 2009; 2011b, p. 8).

In 2010, Noront Resources Ltd. (Toronto) discovered additional nickel-copper-PGE mineralization at its Eagle's Nest deposit in the McFaulds Lake District. The district is located in the James Bay Lowlands, north of the Albany River. The district is the site of two massive chromite zones and a variety of nonferrous metal targets in and around a large ultramafic intrusion—the Ring of Fire (53° N latitude, 86° W longitude). At yearend 2010, the Eagle's Nest had 11.1 Mt of proven and probable reserves averaging 1.68% nickel and 0.87% copper. The reserve figures exclude additional nickel-copper resources at Noront's recent "Eagle Two" and "AT–12" discoveries. Noront was planning to complete a full feasibility study by yearend 2012. The sulfide concentrate would be slurried and pumped through a pipeline from the underground mine to Webequie Junction (Ontario Prospector, The, 2010; Schwartz, 2010; Noront Resources Ltd., 2011a, p. 1, 4–7, 14–19, b).

Quebec.—Xstrata's Raglan Mine in northern Quebec produced 28,237 t of nickel in concentrate, which was 4% less than the 29,262 t recovered in 2009 (Xstrata plc, 2011b, p. 8).

China.—China produced 171,300 t of electrolytic nickel in 2010, up slightly from 170,600 t in 2009. Electrolytic nickel from Jinchuan Non-ferrous Metals Corp. (JNMC) accounted for 129,800 t, or 76% of the national total. JNMC operated the Yongchang mining complex at Jinchang in Gansu Province. Jilin Jien Nickel Industry Co., Ltd. produced about 7,800 t of nickel in salts in 2010, up from 7,200 t in 2009. Jilin Jien had two operations in Jilin Province plus the Siziwngqi Mine in Inner Mongolia. At least five other companies produced primary nickel in China during 2010 (Copper & Nickel Monthly, 2011, p. 14–15).

Chinese demand for primary forms of nickel continued to escalate and was estimated to have reached 575,000 t in 2010, which was 22% greater than that of 2009. The Chinese stainless steel industry accounted for 74% of the country's primary nickel consumption. China was the world's leading stainless-steel-producing country in 2010, with a crude stainless steel output of 12.0 Mt, 26% greater than the 9.55 Mt in 2009. Chinese production of stainless steel has been increasing at an average annual rate of 33% since 2000. Five companies—the Baosteel Group, Henan Tsingshan Jinhui Stainless Steel Industry Co., Ltd., Lianzhong Iron and Steel Co. (LISCO), Taiyuan Iron & Steel (Group) Co., Ltd. (TISCO), and Zhangjiagang Pohang Stainless Steel Co. Ltd. (ZPSS)—accounted for about 68% of the country's stainless steel meltshop production (Vale S.A., 2011c, p. 4, 16, A–37; Eramet Group, 2012, p. 39).

Since 2001, China had consumed more stainless steel annually than any other country. In 2010, China consumed 9.47 Mt of stainless steel, about 37% of the world total and a tonnage larger than the total consumption of Japan, the United States, and Western Europe combined. Chinese imports of stainless steel had been declining since 2006 and decreased to 1.05 Mt in 2010, the lowest level in more than a decade. Exports, in contrast, exceeded imports for the first time since data were made public in 1998 and rose to a record high of 1.43 Mt in 2010 (Vale S.A., 2011c, p. 6–7, 12, 16, A37–A38).

China has a large electroplating industry and a number of rechargeable battery manufacturers that use nickel. China's plating industry accounted for about 12% of the country's primary nickel demand in 2010, while battery manufacturers consumed another 5%. The alloying and foundry sector accounted for the bulk of the remaining 9% (Xu Aidong, 2011, p. 7; Eramet Group, 2012, p. 39).

Since 2005, China's stainless steel producers have been using relatively inexpensive nickeliferous pig iron (NPI) as a substitute for ferronickel and scrap. In 2010, there were more than 200 NPI operations in the country. The two most common grades contained either 4% to 6% nickel or 10% to 15% nickel. The market price for NPI was very close to production costs. At yearend, Tsingshan Holding Group Co., Ltd. commissioned a new NPI operation utilizing EAF technology in Ningde, Fujian Province (Copper & Nickel Monthly, 2011, p. 23–24).

Indonesia.—PT Aneka Tambang Tbk. (Antam) increased production of both limonite and saprolite as sales to NPI producers in China and other overseas customers began to improve. The state-owned company mined 6.99 Mt (wet) of various laterite ores, approaching the alltime high of 7.11 Mt reached in 2007. About 83% of the production was direct shipping ore for export—primarily to Australia, China, Eastern Europe, and Japan. Antam produced 18,688 t of nickel in ferronickel, up 49% from 12,550 t in 2009. Antam's three smelters at Pomalaa had a combined capacity of 26,000 t/yr of nickel in ferronickel (in the form of ingot and shot averaging 19% to 21% nickel). The smelting part of the operation required 70 to 85 wet tons of ore to produce 1 ton of nickel contained in ferronickel (PT Aneka Tambang Tbk., 2011, p. 25, 53–55, 76–77, 80).

PT Vale Indonesia Tbk. (formerly PT Inco) mined 4.18 Mt of ore averaging 2.00% nickel from its Sorowako concessions on Sulawesi. The production figure represents the amount of product delivered to the company's smelter from its adjoining dryer kilns. The smelter produced 78,400 t of nickel in matte for export to Japan, up from 68,800 t in 2009. Vale has a 59% interest in the Indonesian company (Vale S.A., 2011a, p. 38–39).

Madagascar.—The Ambatovy project was in the final stages of construction, with commissioning scheduled for mid-2012. In July, crews began mining and stockpiling ore. At yearend, all of the engineering work was finished and construction was 80% complete. The Ambatovy project was being built around the Sherritt hydrometallurgical process for recovering nickel and cobalt from lateritic ores. The Ambatovy ore was to be piped 220 km from the mining area to the processing plant as a water-based slurry. At the processing plant, the ore would be leached with hot sulfuric acid in autoclaves to produce a mixed sulfide intermediate of nickel and cobalt. The mixed sulfide intermediate would then be dissolved to produce a concentrated solution of nickel and cobalt. The facilities housing the final stage of the operation, in which the cobalt and nickel would be separated by solvent extraction, still needed to be completed (Daigle and others, 2011, p. 152–162; Sherritt International Corp., 2011, p. 2–3, 30, 37).

New Caledonia.—Société Le Nickel (a subsidiary of Eramet) produced 39,802 t of nickel in ferronickel at its Doniambo smelter. The smelter also produced 13,917 t of nickel in matte, which was shipped to Eramet's Sandouville refinery in France for conversion into LME-grade metal and chemicals (Eramet Group, 2011, p. 22–25; International Nickel Study Group, 2011a; b).

At yearend 2010, Vale Nouvelle-Calédonie SAS (VNC, formerly named Goro Nickel SAS) was still conducting performance tests at its new Grand Sud hydrometallurgical plant. Performance testing of the autoclaves began in February, but commissioning of downstream operations was delayed when two solvent extraction columns failed in April. The solvent extraction columns were a critical part of the complex's refining circuit. The mixed hydroxide precipitate circuit in the upstream part of the operation, however, was able to produce 221 t of nickel in a hydroxide cake suitable for further processing at Yabulu. The $4.3 billion mining and processing complex was expected to have a production capacity of 60,000 t/yr of nickel in intermediate product (International Nickel Study Group, 2011b; Vale S.A., 2011a, p. 34–37).

Société Minière du Sud Pacifique and its joint-venture partner, Xstrata, have been developing the Koniambo laterite deposit in the Northern Province since February 2007. Nickel was to be extracted from the saprolite and converted to ferronickel using an improved version of the pyrometallurgical process employed at Xstrata's Falcondo smelting and refining complex in the Dominican Republic. By the beginning of 2010, the bulk of the site infrastructure was completed for the $3.85 billion project. Construction of the smelter and 270 MW powerplant was essentially finished by January 2011. The two plants were assembled onsite from an array of modules built in China and then transported by ship to the new port of Vavouto. Commissioning was scheduled for the second half of 2012. When fully operational, the Koniambo smelter should be capable of producing 60,000 t/yr of nickel in ferronickel shot, which was expected to average 35% nickel, 63% iron, and 0.9% cobalt (Usmar, 2011).

Russia.—About 79% of Norilsk's sales of marketable nickel came from its Russian operations. The other 21% was generated by the company's holdings in Botswana, Finland, and South Africa. Norilsk's Australian subsidiary was on care-and-maintenance status for 2010. Norilsk's operations on the Kola and Taimyr Peninsulas had a combined output of 235,518 t of nickel metal—about 90% of Russia's primary nickel output for the year. Norilsk's two Arctic subsidiaries exported almost all of their nickel production; only about 10,000 t, or less than 5%, was sold to Russian consumers (OJSC MMC Norilsk Nickel, 2011, p. 57–68, 181).

OAO Mechel (Moscow) owned and operated the Southern Urals ferronickel smelter in Orenburg Oblast' and the two laterite mines—Buruktal and Sakahara—that supplied the operation. Mechel produced 16,799 t of nickel in low-iron ferronickel in 2010. An estimated 12,600 t was shipped to the ports of Kaliningrad and St. Petersburg for export to the EU. The remainder was used to make stainless steel at Mechel's stainless steel plant at Chelyabinsk (OAO Mechel, 2011, p. 102–109).

Turkey.— In 2009, Meta Nikel Kobalt A.Ş began mining ore at its Yunusemre open pit operation in Eskisehir Province. The company also applied for the necessary permits needed to construct and operate an ore processing plant near its idled Gordes Mine in Manisa Province. Meta Nikel Kobalt has reportedly completed the environmental impact assessment required by Turkish law in addition to a feasibility study of the plant. Between 2003 and 2008, Meta Nikel Kobalt mined 230,000 t of nickel ore from the Gordes Mine. About 150,000 t of ore was exported, while the remaining 80,000 t was stockpiled. Meta Nikel Kobalt is a subsidiary of Meta Madencilik Ltd. Şti. (Mobbs, 2012, p. 56.3, 56.5).

In December 2010, ENK PLC (formerly European Nickel PLC) placed its innovative Caldag heap-leaching project on care-and-maintenance status. The company had been evaluating the laterite deposit, 15 km north of Turgutlu, since 2002. In 2004, the Government of Turkey issued an environmental license to European Nickel, allowing the company to begin heap leaching on a trial basis. In February 2009, the Government issued the key forestry permit required to begin construction and full development. In June 2010, however, the Turkish parliament passed a new mining law that required EKN to apply for an updated forestry permit. The new permit was never issued, forcing EKN to reassess the viability of the Caldag project. The project was to have produced 21,000 t/yr of nickel in a mixture of nickel and cobalt hydroxide. Also in June, European Nickel merged with Rusina Mining NL (West Perth, Australia) and began focusing its resources on a similar heap-leaching project in the Philippines (ENK PLC, 2010; Olchondra, 2010).

Outlook

U.S. nickel consumers will probably be dependent on foreign sources of refined metal and ferronickel for at least the next 25 years. The ongoing expansion of nickel laterite mining operations in Brazil, Indonesia, New Caledonia, and other tropical countries will help meet the increasing demand for nickel worldwide. The nickel output from both Vale's state-of-the-art leach facility in New Caledonia and the company's new Long Harbour plant in Newfoundland is expected to satisfy the near-term rise in global demand projected after 2014. Long-range forecasts of increasing usage in Asia have encouraged parastatal companies in China to fund the development of greenfield laterite mines in Burma, Papua New Guinea, and Turkey. European and North American companies were seriously considering funding large-scale laterite projects in Cameroon, Guatemala, the Philippines, and Tanzania.

Exploration companies have begun showing renewed interest in the nickel mineralization of Côte d'Ivoire, especially deposits near Biankouma and Yoroudougou.

Sulfide mines approaching the end of their productive lives because of dwindling reserves and high operating costs continue to be replaced. Developments of high-grade sulfide deposits, however, are becoming less frequent because the deposits are harder to find and located farther from shipping routes. These new projects are more costly to finance owing to their remoteness, stricter environmental regulations, and increased technical complexity. Advances in extraction technology may offer a solution. As a result of advances in bioengineering, large-tonnage, low-grade polymetallic sulfide ore deposits like those at Sotkamo, Finland, previously passed over, are now amenable to bioheapleaching.

Concerns about global warming and associated climate changes have encouraged research, development, and construction in the renewable energy sector. In recent years, Congress and several Executive Departments have supported a variety of initiatives designed to encourage increased development and expanded use of renewable energy in the United States. This support was being driven in part by concerns about continued U.S. reliance on imported petroleum products, rising energy costs worldwide, and the possible contribution of fossil fuel combustion products to global climate change. The retrofitting of coal-fired powerplants to reduce carbon dioxide emissions remains a national issue (Deutch and Moniz, 2009). Many older coal-fired powerplants in the United States do not meet current environmental standards, cannot be economically renovated, and are scheduled to be retired. State-of-the-art powerplants fired by natural gas will replace some of these coal-based facilities.

Global demand for electricity, however, continues to increase. To meet demand, the power industry will have to build many more generating stations—stations that either operate on renewable energy (geothermal, solar, or wind) or are designed to better utilize uranium or thorium (safer, fourth generation nuclear reactors). Development of advanced coal-fired plants, especially ones that operate with ultra-supercritical steam, would also help. All of this construction would require large tonnages of nickel-bearing stainless steel and superalloys (Kirsch, 2009; Wong and Coates, 2010).

Demand for nickel in the transportation sector is also expected to increase. Chinese, European and North American usage of nickel- and cobalt-base superalloys was expected to escalate between 2013 and 2017, largely because of increasing demand for new jet aircraft that have more-fuel-efficient engines. The Boeing Co. and Airbus S.A.S. both have a large backlog of jet-aircraft orders. Boeing forecasts an average growth rate of 5% to 6% per year for global passenger and cargo air traffic between 2011 and 2031. An estimated 33,500 new airplanes would have to be built during the 20-year period to meet demand. Some energy analysts have predicted that world crude oil production may peak a decade earlier than predicted—perhaps as soon as 2014. Significantly higher gasoline prices could encourage the replacement of conventional automobile steel frames with lighter ones fabricated from stronger stainless steel. The burgeoning development of renewable energy sources was expected to accelerate research on cost-effective, more advanced batteries, especially for automobiles and remote power stations (Nashawi, Malallah, and Al-Bisharah, 2010; Boeing Co., The, 2012, p. 22–26).

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Roskill Information Services Ltd.

TABLE 1
SALIENT NICKEL STATISTICS[1]

(Metric tons of contained nickel unless otherwise specified)

		2006	2007	2008	2009	2010
United States:						
Secondary recovery from purchased scrap:						
From ferrous scrap		94,000	84,600 [r]	77,500 [r]	72,100 [r]	95,900
From nonferrous scrap		9,630 [r]	9,340 [r]	9,250 [r]	7,730 [r]	8,640
Shipments of purchased scrap[2]		143,000 [r]	181,000 [r]	161,000 [r]	152,000	161,000
Exports:						
Primary		8,050	13,100	11,600	7,020	12,600
Secondary		59,300	103,000	94,600	90,000	80,300
Imports for consumption:						
Primary		153,000	125,000	129,000	99,900	129,000
Secondary		20,300	16,200	20,100	17,700	23,800
Consumption:						
Reported:						
Primary		103,000 [r]	103,000 [r]	104,000	83,800 [r]	97,500
Secondary, purchased scrap		104,000 [r]	94,000 [r]	86,700 [r]	79,900 [r]	105,000
Total		206,000 [r]	197,000 [r]	190,000 [r]	164,000 [r]	202,000
Apparent, primary		144,000	112,000	115,000	93,900 [r]	113,000
Apparent primary plus reported secondary		247,000	206,000 [r]	202,000 [r]	174,000 [r]	218,000
Stocks, yearend:						
Producers and traders		6,450	5,690	5,860	5,490 [r, p]	6,240
Consumer, primary		7,680 [r]	7,460 [r]	9,290 [r]	8,580 [r]	11,200
Consumer, secondary		6,420	6,600 [r]	6,320 [r]	5,520 [r]	6,140
Total		20,500	19,700 [r]	21,500 [r]	19,600 [r]	23,600
Price, cash, London Metal Exchange:						
Average annual	dollars per metric ton	24,244	37,216	21,104	14,649	21,804
Average annual	dollars per pound	10.997	16.881	9.572	6.645	9.890
Price, 18/8 stainless steel scrap, 304, gross weight:[3]						
Average annual	dollars per metric ton	2,057	2,952	2,361	1,462	2,200
Average annual	dollars per long ton	2,090	2,999	2,399	1,486	2,235
World, mine production		1,570,000	1,650,000 [r]	1,580,000 [r]	1,410,000 [r]	1,620,000

[p]Preliminary. [r]Revised.

[1] Data are rounded to no more than three significant digits; except prices; may not add to totals shown.

[2] Defined as scrap receipts less shipments by consumers plus exports minus imports plus adjustments for consumer stock changes.

[3] Derived from the average of the Friday consumer buying price range for 18% chromium, 8% nickel scrap in bundles, solids, and clips, Pittsburgh PA, in American Metal Market (AMM). On November 1, 2006, AMM began reporting prices for Type 316 solids & clips and has changed its listing for 18/8 bundles, solids & clips to Type 304 solids & clips.

TABLE 2

NICKEL RECOVERED FROM PURCHASED SCRAP IN THE UNITED STATES, BY KIND OF SCRAP AND FORM OF RECOVERY[1]

(Metric tons of contained nickel)

	2009	2010
Kind of scrap:		
Aluminum-base[2]	1,620 [r]	1,690
Copper-base	1,160	1,280
Ferrous-base[3]	72,100 [r]	95,900
Nickel-base	4,950 [r]	5,680
Total	79,900 [r]	105,000
Form of recovery:		
Aluminum-base alloys	1,620 [r]	1,690
Copper-base alloys	1,890 [r]	2,080
Ferrous alloys	72,200 [r]	96,900
Nickel-base alloys	4,180 [r]	3,920
Total	79,900 [r]	105,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Primarily borings and turnings of wrought alloys, such as 2218, 2618, 4032, and 8280, or special casting alloys, such as 203.0.

[3] Primarily stainless and alloy steel scrap consumed at steel mills and foundries.

TABLE 3

REPORTED U.S. CONSUMPTION OF NICKEL, BY FORM[1]

(Metric tons of contained nickel)

Form	2009	2010
Primary:		
Metal	72,800 [r]	83,600
Ferronickel	9,210 [r]	11,400
Oxide and oxide sinter[2]	116 [r]	214
Chemicals	864	1,270
Other	842 [r]	1,020
Total	83,800 [r]	97,500
Secondary, scrap[3]	79,900 [r]	105,000
Grand total	164,000 [r]	202,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes chemical-grade oxide.

[3] Based on gross weight of purchased scrap consumed and estimated average nickel content.

TABLE 4
U.S. CONSUMPTION OF NICKEL, BY USE[1]

(Metric tons of contained nickel)

	2010								Grand total in 2009
Use	Metal	Ferronickel	Oxide and oxide sinter	Chemicals	Other forms	Total primary	Secondary (scrap)	Grand total	
Consumption reported:									
Cast irons[2]	61	--	--	--	W	61	227	288	204[r]
Chemicals and chemical uses	919	--	W	W	W	919	--	919	1,740
Electric, magnet, expansion alloys	211	W	--	--	--	211	1	212	141
Electroplating, sales to platers	7,200	--	--	W	W	7,200	--	7,200	11,500
Nickel-copper and copper-nickel alloys	1,450	--	W	W	W	1,450	2,080	3,530	2,870[r]
Other nickel and nickel alloys	15,900	W	W	--	52	15,900	W	15,900	20,100[r]
Steel:									
Stainless and heat resistant	33,500	11,100	W	--	163	44,700	94,700	139,000	104,000
Alloys, excludes stainless	W	W	--	--	--	W	1,430	1,430	6,330[r]
Superalloys	20,100	W	--	1	593	20,700	W	20,700	13,000[r]
Other[3]	4,330	323	212	1,270	214	6,350	6,140	12,500	4,180[r]
Total	83,600	11,400	212	1,280	1,020	97,500	105,000	202,000	164,000[r]

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Under investigation.

[3] Includes batteries, catalysts, ceramics, coinage, other alloys containing nickel, and data indicated by symbol W.

TABLE 5
NICKEL IN CONSUMER STOCKS IN THE UNITED STATES, BY FORM, DECEMBER 31[1]

(Metric tons of contained nickel)

Form	2009	2010
Primary:		
Metal	6,330[r]	8,350
Ferronickel	733	821
Oxide and oxide sinter	75[r]	82
Chemicals	1,350	1,840
Other	96[r]	91
Total	8,580[r]	11,200
Secondary, scrap	5,520[r]	6,140
Grand total	14,100[r]	17,300

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 6
U.S. EXPORTS OF NICKEL PRODUCTS, BY CLASS[1]

Class	2009		2010	
	Quantity (metric tons of contained nickel)	Value (thousands)	Quantity (metric tons of contained nickel)	Value (thousands)
Primary:				
Unwrought:				
Cathodes, pellets, briquets, shot	1,100	$16,800	1,310	$28,300
Ferronickel	32	1,050	30	1,280
Powder and flakes	1,110	46,700	1,530	67,000
Metallurgical-grade oxide[2]	627	4,850	5,440	33,000
Chemicals:[2]				
Catalysts	2,870	221,000	2,920	184,000
Salts[3]	1,280	22,500	1,410	31,100
Total	7,020	313,000	12,600	345,000
Secondary:[2]				
Stainless steel scrap	84,800	777,000	70,300	936,000
Waste and scrap	5,170	36,200	10,000	95,000
Total	90,000	814,000	80,300	1,030,000
Grand total	97,000	1,130,000	93,000	1,380,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	233	6,510	305	7,960
Sheets, strip, foil	546	13,100	548	17,000
Tubes and pipes	197	4,630	1,050	10,400
Total	975	24,200	1,900	35,400
Alloyed, gross weight:				
Unwrought alloyed ingot	5,740	128,000	4,510	108,000
Bars, rods, profiles, wire	12,700	414,000	15,200	507,000
Sheets, strip, foil	6,240	197,000	9,270	282,000
Tubes and pipes	1,920	106,000	2,300	99,200
Other alloyed articles	4,110	277,000	3,250	324,000
Total	30,700	1,120,000	34,500	1,320,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The nickel contents are as follows: metallurgical-grade oxide, 77%; waste and scrap, 50%; and stainless steel scrap, 7.5%. The salts category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; and sulfates, 22%. Other salts and various catalysts are assumed to be 22% nickel.

[3] Excludes nickel carbonate.

Source: U.S. Census Bureau.

TABLE 7
U.S. EXPORTS OF NICKEL PRODUCTS, BY COUNTRY[1]

(Metric tons of contained nickel)[2]

	2010									
Country	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical-grade oxide[3]	Waste and scrap	Stainless steel scrap	Chemicals	Total	Total in 2009	Wrought nickel in 2010[4]
Australia	--	10	--	--	639	5	9	663	426	3
Belgium	18	4	(5)	12	62	108	328	532	431	1
Brazil	149	41	(5)	--	--	2	203	395	409	34
Canada	23	146	--	2,030	5,920	1,610	860	10,600	5,700	256
China	4	199	--	2	74	6,460	257	7,000	18,700	71
Colombia	52	19	--	--	--	4	26	101	74	35
Finland	--	(5)	--	--	21	3,180	--	3,210	2,260	1
France	--	28	--	--	10	45	3	86	77	9
Germany	6	349	--	2	294	25	230	906	657	56
India	2	92	--	2	29	1,870	272	2,270	9,460	9
Italy	--	2	--	--	9	23	32	66	52	(5)
Japan	12	60	--	3,370	1,610	5,780	88	10,900	3,690	43
Korea, Republic of	3	60	--	(5)	24	10,500	55	10,700	11,800	273
Mexico	848	38	(5)	(5)	5	72	728	1,690	1,180	133
Netherlands	1	2	--	--	356	893	77	1,330	393	68
South Africa	1	3	--	2	--	--	12	18	12	(5)
Spain	--	2	--	--	--	974	17	993	814	6
Sweden	--	8	--	--	122	214	(5)	344	380	--
Taiwan	10	26	--	(5)	19	33,900	186	34,100	29,800	37
Thailand	--	87	(5)	--	2	196	39	324	2,260	9
United Kingdom	94	94	27	3	762	117	102	1,200	708	48
Other	90	259	3	25	82	4,310	797	5,570	7,650	812
Total	1,310	1,530	30	5,440	10,000	70,300	4,320	93,000	97,000	1,900

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The nickel contents are assumed to be as follows: metallurgical-grade oxide, 77%; waste and scrap, 50%; and stainless steel scrap, 7.5%. The chemicals category contains the following: chemical-grade oxide, sesquoxide, and hydroxide, 65%; chlorides, 25%; and sulfate, 22%. Other salts and various catalysts are assumed to be 22% nickel.

[3] Chemical-grade oxide is included in the "Chemicals" category.

[4] Excluded from "2010, total."

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY CLASS[1]

	2009		2010	
Class	Quantity (metric tons of contained nickel)	Value (thousands)	Quantity (metric tons of contained nickel)	Value (thousands)
Primary:				
Unwrought:				
Cathodes, pellets, briquets, shot	85,500	$1,210,000	110,000	$2,320,000
Ferronickel	6,200	84,900	9,420	186,000
Powder and flakes	4,450	83,700	6,290	163,000
Metallurgical-grade oxide[2]	799	10,800	77	1,610
Chemicals:[2]				
Catalysts	1,900	78,200	1,690	85,500
Salts[3]	1,010	17,400	1,440	33,000
Total	99,900	1,480,000	129,000	2,790,000
Secondary:[2]				
Stainless steel scrap	9,310	138,000	14,600	305,000
Waste and scrap	8,430	112,000	9,130	167,000
Total	17,700	249,000	23,800	472,000
Grand total	118,000	1,730,000	153,000	3,260,000
Wrought, not alloyed:				
Bars, rods, profiles, wire	131	4,260	248	8,360
Sheets, strip, foil	195	5,180	340	9,810
Tubes and pipes	83	4,590	89	2,960
Total	409	14,000	677	21,100
Alloyed, gross weight:				
Unwrought alloyed ingot	4,590	63,600	6,860	135,000
Bars, rods, profiles, wire	6,450	151,000	8,540	210,000
Sheets, strip, foil	1,790	41,900	2,570	57,700
Tubes and pipes	1,670	95,500	1,680	64,000
Other alloyed articles	2,820	87,700	1,830	98,900
Total	17,300	439,000	21,500	565,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The nickel contents are as follows: metallurgical-grade oxide from Australia, 90%; elsewhere, 77%. The salts category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%; and other salts, which are assumed to be 22% nickel. The typical catalyst is assumed to have a nickel content of 22%. Waste and scrap is assumed to be 50% nickel; stainless steel scrap, 7.5% nickel.

[3] Excludes nickel carbonate.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF NICKEL PRODUCTS, BY COUNTRY[1]

(Metric tons of contained nickel)[2]

	2010									
Country	Cathodes, pellets, and briquets (unwrought)	Powder and flakes	Ferronickel	Metallurgical-grade oxide[3]	Waste and scrap	Stainless steel scrap	Chemicals	Total	Total in 2009	Wrought nickel in 2010[4]
Australia	16,300	603	--	65	67	--	--	17,000	10,600	--
Belgium	--	165	--	--	5	3	208	381	426	(5)
Brazil	3,410	--	--	--	110	35	--	3,550	1,770	--
Canada	17,300	1,680	19	7	1,920	8,510	95	29,500	46,700	7
Colombia	--	--	5,210	--	10	4	--	5,230	3,800	--
Dominican Republic	--	--	--	--	11	16	--	27	238	--
Finland	5,900	16	--	--	(5)	--	357	6,270	5,780	--
France	1,400	1	--	--	1,010	8	378	2,800	2,420	223
Germany	1,050	108	--	--	761	--	343	2,260	1,230	237
Indonesia	--	--	546	--	--	--	3	549	149	--
Israel	--	13	--	--	212	24	--	249	94	--
Italy	--	10	--	--	108	--	40	158	34 r	3
Japan	1,130	132	--	--	406	3	121	1,790	1,040	27
Mexico	4	--	1	--	678	5,290	24	6,000	2,710	(5)
Netherlands[6]	62	20	--	(5)	106	--	481	668	342	1
New Caledonia	--	--	3,530	--	--	--	--	3,530	1,800	--
Norway	25,000	--	--	--	--	--	--	25,000	11,300	--
Russia	32,300	1,390	--	--	114	--	--	33,800	20,700	(5)
South Africa	422	284	108	--	--	--	--	814	585	--
Spain	--	--	--	--	83	--	(5)	83	65 r	2
Taiwan	--	1	--	--	122	271	(5)	394	146	--
United Kingdom	3,140	1,670	--	6	1,860	77	126	6,870	2,580	36
Zimbabwe	753	--	--	--	--	--	9	762	514	--
Other	1,980	204	--	--	1,560	396	937	5,070	2,510	141
Total	110,000	6,290	9,420	77	9,130	14,600	3,120	153,000	118,000	677

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The nickel contents are assumed to be as follows: metallurgical-grade oxide from Australia, 90%; elsewhere, 77%. The chemicals category contains the following: chemical-grade oxide, sesquioxide, and hydroxide, 65%; chlorides, 25%; sulfates, 22%. Other salts and various catalysts are assumed to be 22% nickel. Waste and scrap is assumed to be 50% nickel; stainless steel scrap, 7.5% nickel.

[3] Primarily oxide, rondelles, and sinter.

[4] Excluded from "2010, total."

[5] Less than ½ unit.

[6] The different nickel products (cathode, powder, etc.) are apparently materials that have transited through bonded warehouses in the Netherlands, including warehouses overseen by the London Metal Exchange.

Source: U.S. Census Bureau.

TABLE 10
NICKEL: WORLD MINE PRODUCTION, BY COUNTRY[1]

(Metric tons of contained nickel)

Country and products[2]	2006	2007	2008	2009	2010
Albania, laterite ore[e]	790	3,700	3,500	3,500	3,500
Australia, ores and concentrate[3]	185,000	184,900	199,200	165,000	170,000 [e]
Botswana, ore milled[e]	38,000	27,600	28,940 [4]	28,595 [4]	28,000
Brazil, ore	82,492	58,317	67,116 [r]	41,059 [r]	108,983 [p]
Burma, ore[e]	10	10	10	10	10
Canada, concentrate	232,948	254,915	259,651	136,594	158,376 [p]
China[e]	82,100	67,000	79,500 [r]	84,800 [r]	80,000
Colombia, laterite ore	94,105	75,864 [r]	64,200 [r]	79,900 [r,e]	76,200 [e]
Cuba, oxide, oxide sinter, oxide powder, sulfide, ammoniacal liquor[5]	73,371	73,934	67,265	70,000 [r,e]	71,000 [e]
Dominican Republic, laterite ore	47,516	47,125	31,300	500 [r]	--
Finland, concentrate[6]	2,985	3,465 [r]	4,303	4,400 [e]	4,000 [e]
Greece, laterite ore	21,670	21,190	18,646 [r]	10,203 [r]	16,345 [p]
Indonesia, laterite ore[e]	157,200 [r,4]	229,200 [r,4]	219,300 [r]	202,800	235,800
Kazakhstan, laterite ore[e]	200	200	500	500	500
Kosovo, laterite ore	--	1,820	3,660 [7]	10,500 [r,7]	9,080 [7]
Macedonia, ferronickel produced[8]	10,942	15,321	15,026	12,000 [r]	14,000 [e]
Madagascar, laterite ore	--	--	--	--	2,100 [e]
Morocco, nickel sulfate[e]	80 [4]	80 [r]	100	100	100
New Caledonia, ore	102,986	125,364	102,583	92,570 [r]	129,983
Norway, concentrate	362 [r]	246 [r]	377	336 [r]	350
Philippines:					
Ore	56,463 [r]	81,288 [r]	70,082	122,709 [r]	153,679
Concentrate[9]	8,242	10,079	10,562	17,035	19,312
Total	64,705 [r]	91,367 [r]	80,644	139,744 [r]	172,991
Russia, marketable mine production:					
Laterite ore[10]	37,758 [r]	45,687 [r]	36,804 [r]	32,298 [r]	41,184
Sulfide concentrate[11]	239,231	234,083	229,765 [r]	229,493	228,093
Total	276,989 [r]	279,770 [r]	266,569 [r]	261,791 [r]	269,277
South Africa, concentrate	41,599	37,917	31,675	34,605 [r]	39,960
Spain, concentrate	6,398	6,772	8,136	8,029	6,296
Turkey, laterite ore[e, 12]	1,500	--	--	--	--
Ukraine, laterite ore[e]	12,000	12,000	8,000	--	--
Venezuela, laterite ore	21,200	18,900	13,000	13,200	11,400
Zambia, concentrate[13]	--	--	751	280 [r,e]	2,809
Zimbabwe, concentrate	8,825	8,582	6,354	4,858 [r]	6,200
Grand total	1,570,000	1,650,000 [r]	1,580,000 [r]	1,410,000 [r]	1,620,000
Of which:					
Concentrate[14]	541,000	556,000	552,000	436,000	465,000
Ore and ore milled	280,000 [r]	293,000 [r]	269,000 [r]	285,000 [r]	421,000
Laterite ore	394,000	456,000 [r]	399,000 [r]	353,000 [r]	396,000
Ferronickel produced	10,900	15,300	15,000	12,000	14,000 [e]
Nickel sulfate[e]	80 [4]	80 [r]	100	100	100
Unspecified and (or) undifferentiated	340,000	326,000	346,000 [r]	320,000 [r]	321,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Insofar as possible, this table represents recoverable mine production of nickel. Where actual mine output is not available, data related to a more highly processed form have been used to provide an indication of the magnitude of mine output and this is noted. North Korea may have an active nickel mine, but information is inadequate to make reliable estimates of output. Table includes data available through January 31, 2012.

[3] Australian Bureau of Agricultural and Resource Economics (ABARE) data for mines in Western Australia and Tasmania.

[4] Reported figure.

TABLE 10—Continued

NICKEL: WORLD MINE PRODUCTION, BY COUNTRY[1]

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[5] The Government of Cuba reports figures of nickel-cobalt content of granular and powder oxide, oxide sinter, and sulfide production. The cobalt content of reported nickel-cobalt production was determined to be 1.2% for granular and powdered oxide, 1.2% for oxide sinter, 7.6% for sulfide precipitate, and 33% for leach ammoniacal precipitate. The remainder of reported figures represents the nickel content.

[6] The gross weight of concentrates processed in Finland from domestic ores was, in metric tons, as follows: 2006—40,474; 2007—44,824; 2008—43,038; 2009—43,000 (estimated); and 2010—40,800 (estimated).

[7] On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

[8] Cunico Resources Group extracts nickel ore from its open pit Rzanovo Mine and transports the ore by conveyor to its FeNi Industries pyrometallurgical facility in Kavadarci. At the Kavadarci plant, the Rzanovo ore is blended with higher grade imported ores from Albania, Indonesia, New Caledonia, and Turkey to optimize production.

[9] Nickel content of concentrate produced at Rio Tuba in 2006–10 by Coral Bay Nickel Corp.

[10] Nickel content of ore mined in the Ural Mountains region.

[11] Nickel content of concentrate produced on the Kola and Taimyr Peninsulas.

[12] European Nickel PLC began shipping laterite ore from the Caldag Mine to the ferronickel smelter of Larco General Mining and Metallurgical Company S.A. in Greece in 2006.

[13] Albidon Limited concentrates were shipped to Jinchuan, China. First production was in June 2008. Anticipated specifications for concentrates are 13% nickel and 0.7% cobalt. Concentrate production comes from company quarterly reports.

[14] Includes "Russia, sulfide concentrate."

TABLE 11

NICKEL: WORLD PRODUCTION OF INTERMEDIATE PRODUCTS FOR EXPORT, BY COUNTRY[1, 2]

(Metric tons of contained nickel)

Country	2006	2007	2008	2009	2010
Matte:					
Australia[3]	39,561	41,612	31,085	35,441	76,290 [p]
Botswana	26,762	22,844	28,940	29,616	29,000
Brazil[4]	5,416	3,401	8,328 [r]	8,518 [r]	14,308 [p]
Canada[5]	56,628	73,922	76,908	68,972	70,127 [p]
China[6]	758	1,980	3,240	--	1
Indonesia[7]	72,782	77,928	73,356	68,228 [r]	77,186
New Caledonia	13,655	14,842	13,564	13,902	13,917
Russia[8]	1,300 [9]	670	600	240	206
Zimbabwe[e, 10]	1,600	1,600 [r]	1,700 [r]	2,200 [r]	3,500
Total	218,000	239,000	238,000 [r]	227,000 [r]	285,000
Other, Cuba:[11]					
Sulfide precipitate	30,967	31,116	32,465	33,600 [r]	34,000 [p]
Ammoniacal liquor precipitate	3,283	2,907	322	300 [e]	300 [e]
Total	34,250	34,023	32,787	33,900 [r, e]	34,300 [e]

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] Table includes data available through January 31, 2012. Data represent nickel content of matte and other intermediate materials produced.

[2] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[3] Figures exclude toll-refined material. Total matte production on a contained nickel basis, in metric tons, was as follows: 2006—39,000; 2007—42,000; 2008—31,000; 2009—28,000 (revised); and 2010—54,000.

[4] Represents the output of the Fortaleza smelter. All of the Fortaleza matte is shipped to Finland for further processing.

[5] Nickel content of reported exports. Matte from the smelter at Falconbridge typically assays 55% nickel.

[6] Chinese exports were estimated to have a nickel content of 63%. Total matte production on a contained nickel basis, in metric tons, was estimated as follows: 2006—99,800; 2007—105,000; 2008—114,000 (revised); 2009—120,000 (revised); and 2010—125,000.

[7] Represents the nickel output of the Soroako smelter. The Soroako matte is shipped to Japan for further processing and contains on average 78% nickel.

[8] Primarily exports to China. Sources: International Nickel Study Group; United Nations Statistics Division.

[9] Reported figure.

[10] Zimplats material shipped to the Impala Refinery at Springs, South Africa.

[11] Corrected to remove coproduct cobalt.

TABLE 12

NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT [1, 2]

(Metric tons of contained nickel)

Country and product[3]	2006	2007	2008	2009	2010
Australia:					
Metal	105,100	100,300	89,500	123,200	98,000
Unspecified[4]	11,400	14,200	19,400	8,000	10,000
Total	116,500	114,500	108,900	131,200	108,000
Austria, ferronickel and ferronickel molybdenum[e]	900	900	800 [r]	700	600
Brazil:[5]					
Ferronickel	9,814	9,918	9,136 [r]	9,427 [r]	8,465 [p]
Metal	21,339	21,635	18,530	16,598 [r]	19,111 [p]
Total	31,153	31,553	27,666 [r]	26,025 [r]	27,576 [p]
Canada, unspecified[6]	146,899	153,647	167,732	116,909	105,413 [p]
China:[7]					
Ferronickel and high nickel pig iron	31,000	84,500	70,900	100,000	150,000
Metal	102,000	116,000	129,000	165,000	172,000
Chemicals and unspecified[e]	5,000	6,000 [8]	8,000 [8]	8,000	8,500
Total	138,000	206,500	207,900	273,000	330,500
Colombia, ferronickel	51,137	49,314	41,636	51,802	49,443
Cuba, oxide sinter and oxides[9]	39,121	39,911	34,478	32,800 [r, e]	34,000 [e]
Dominican Republic, ferronickel	29,675	29,130 [r]	18,782 [r]	--	--
Finland:[10]					
Metal	42,299	49,758 [r]	36,181 [r]	41,848	42,000 [e]
Chemicals and unspecified	5,170	5,206 [r]	6,855 [r]	5,000	7,160 [e]
Total	47,469	54,964 [r]	43,036 [r]	46,848	49,159 [p]
France:					
Metal[e]	11,700 [r, 8]	11,200	11,400 [r]	12,000 [r, 8]	10,800
Chemicals[e]	1,620 [r]	2,020 [r]	1,840 [r]	1,960 [r]	2,080
Total[11]	13,319 [r]	13,218 [r]	13,236 [r]	13,955 [r]	12,879
Greece, ferronickel	17,740	18,670	16,650 [r]	8,269 [r]	13,975
India:[12]					
Ferronickel	(13)	(13)	(13)	(13)	(13)
Ferronickel magnesium	41	52	93	88	90
Nickel sulfate	(14)	(14)	(14)	(14)	(14)
Total	41	52	93	88	90
Indonesia, ferronickel	14,474	18,532	17,566	12,550	18,688
Japan:					
Ferronickel	66,668	68,346	59,259	54,491 [r]	64,349
Metal	29,254	30,402	34,861	29,351 [r]	40,228
Oxide sinter	53,800 [r]	60,151	60,000 [r, e]	58,000 [r, e]	59,000 [e]
Chemicals	2,531	2,270	2,333	1,669 [r]	2,497
Total	152,253 [r]	161,169	156,000 [r, e]	144,000 [r, e]	166,000 [e]
Korea, Republic of:					
Ferronickel	--	--	2,506	21,609	20,965 [p]
Metal	(15)	(15)	(15)	(15)	(15)
Total	(15)	(15)	2,506	21,609	20,965 [p]
Kosovo, ferronickel[e]	--	800	5,600 [r, 16]	6,360 [r, 16]	7,000
Macedonia, ferronickel	10,942	15,321	15,026	12,000 [r]	14,000 [e]
Morocco, chemicals[e]	125	125	125	125	125
New Caledonia, ferronickel	48,723	44,954	37,467	38,230	39,802
Norway, metal	81,974	87,590	88,741	88,577	92,185
Poland, chemicals[e, 17]	465 [8]	475	475	475	475
Russia:					
Ferronickel					
High-nickel	14,436	17,111	16,158	15,565	16,799
Other[18]	4,490	4,690	4,905	5,125	5,330

See footnotes at end of table.

TABLE 12—Continued

NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT [1, 2]

(Metric tons of contained nickel)

Country and product[3]	2006	2007	2008	2009	2010
Russia—Continued:					
Metal	255,045	248,363	242,409	239,269 [r]	245,543
Oxide sinter	2,713	235	--	--	--
Chemicals[e]	3,500	3,100	2,900	2,700	2,700
Total	280,184	273,499	266,372	262,659 [r]	270,372
South Africa:					
Ferronickel, high-nickel	100	5,000	4,300	800	780
Metal	42,000 [r]	39,800 [r]	32,300 [r]	36,500 [r]	35,700 [e]
Chemicals[e, 19]	6,360 [r]	6,610 [r]	4,450 [r]	4,850 [r]	4,790
Total	48,460 [r]	51,410 [r]	41,050 [r]	42,150 [r]	41,300 [e]
Taiwan, metal	(15)	(15)	(15)	(15)	(15)
Ukraine, ferronickel[20]	15,223	14,211 [r]	16,224	12,392	12,400 [e]
United Kingdom, metal[21]	36,770	34,064	38,700 [r]	38,000 [r, e]	38,000 [e]
Venezuela, ferronickel	16,600	15,700	10,900	10,400	11,700 [p]
Zimbabwe, metal:[e]					
Refined from domestic nickel ore	5,510 [8]	4,500	3,400	--	--
Toll refined from imported nickel feed[22]	9,000	9,500	10,300	6,000 [r]	4,064 [8]
Total	14,510 [8]	14,000	13,700	6,000 [r]	4,064 [8]
Grand total	1,350,000	1,440,000	1,390,000 [r]	1,400,000 [r]	1,470,000
Of which:					
Ferronickel, including ferronickel magnesium, ferronickel molybdenum, and high nickel pig iron	332,000	397,000 [r]	348,000 [r]	360,000 [r]	434,000
Metal	742,000 [r]	753,000 [r]	735,000 [r]	796,000 [r]	798,000
Oxide sinter	95,600 [r]	100,000	94,500 [r]	90,800 [r]	93,000
Chemicals, including nickel sulfate	14,600 [r]	14,600 [r]	12,100 [r]	11,800 [r]	12,700
Unspecified	168,000	179,000	202,000 [r]	138,000	131,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through August 12, 2011.

[3] In addition to the countries listed, North Korea is thought to have produced metallic nickel and (or) ferronickel, but information is inadequate to make reliable estimates of output levels. Several countries produce nickel-containing matte, but output of nickel in such materials has been excluded from this table to avoid double counting. Countries producing matte for export are listed in table 11.

[4] Class II products with a nickel content of less than 99%. Includes oxides and oxide sinter. Excludes intermediate nickel-cobalt sulfide matte, regulus, and speiss for further refining.

[5] Brazil produced nickel carbonate (an intermediate product for metal production), in metric tons: 2006—21,630; 2007—20,796; 2008—18,580 (revised); 2009—16,766 (revised); and 2010—21,800 (estimated).

[6] Nickel contained in products of smelters and refineries in forms that are ready for use by consumers. Figures include the nickel content of nickel oxide sinter exported to the Republic of Korea and Taiwan. More information can be found in footnote 15.

[7] Preliminary figures for ferronickel and chemicals were derived from data published by Beijing Antaike Information Development Co. Ltd. Figures for electrolytic and other class I nickel are based on data provided by the China Nonferrous Metals Industry Association and the International Nickel Study Group. In 2006–10, China also produced nickeliferous pig iron from lateritic ores imported from Indonesia, New Caledonia, and the Philippines.

[8] Reported figure.

[9] Cuba also produces nickel sulfide and ammoniacal liquor precipitate, but because they are used as feed material elsewhere, they are not included to avoid double counting. More information can be found in table 11.

[10] Most of the production is extracted from imported raw materials.

[11] Reported by Eramet for Sandouville. Excludes secondary production from spent rechargeable batteries.

[12] India's fiscal year ending March 31 of that year stated.

[13] Vidarbha Nickel Pvt. Ltd. of Nagpur, Maharashtra State, has been producing ferronickel from spent nickel catalysts, but no production data were available. The ferronickel typically contains 47% to 50% nickel.

[14] In India, nickel sulfate has been produced in the past as a byproduct at the Ghatsila copper smelter in Jharkhand State. The facility is capable of producing 390 tons (gross weight) per year of nickel sulfate, but no production has been reported since 2005.

TABLE 12—Continued

NICKEL: WORLD PLANT PRODUCTION, BY COUNTRY AND PRODUCT [1, 2]

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[15] Nickel metal production for the Republic of Korea and Taiwan are not included because the production is derived wholly from imported metallurgical-grade oxides and to include them would result in double counting. Metal estimates are as follows, in metric tons: Republic of Korea: 2006—28,085; 2007—28,675; 2008—28,653; 2009—20,900 (revised estimate); and 2010—22,000 (estimated). Taiwan: 2006—11,000 (estimated); 2007—11,000 (estimated); 2008—11,000 (estimated); 2009—11,000 (estimated); and 2010—11,000 (estimated).

[16] On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

[17] Nickel content of nickel sulfate. Most of the nickel sulfate was a byproduct of the concentrating, smelting, and refining of domestically mined copper ores. Some production, however, may have been derived from imported nickeliferous raw materials that were blended with the domestic copper concentrates.

[18] Includes ferronickel chromium and Ni-resist cast iron.

[19] Includes nickel sulfate plus exported metal in concentrate.

[20] May include nickel in remelt alloys derived from scrap.

[21] Tonnages include nickel contents of chemicals.

[22] Data represent production from matte imported from Botswana and nickel sulfate imported from South Africa.

TABLE 13
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

Projected year of first production	Country (state/province)	Project and company[1]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[2]	Annual production capacity (metric tons of contained nickel)	Nickel product
2010–11	Brazil (Pará)	Onca-Puma Vale Nickel	1.73 1.76	110,000 59,000	53,000	Ferronickel.
2010–12	New Caledonia (Southern)	Vale Nouvelle-Calédonie (formerly Goro)[3] Vale Nickel, Société de Participation Minière du Sud Calédonien S.A.S., and SUMIC Netherlands Nickel B.V. (a joint venture of Sumitomo Metal Mining Co., Ltd. and Mitsui & Co., Ltd.)	1.34 2.01 1.70	96,000 24,000 83,000	60,000	Nickel-cobalt hydroxide, initially. Nickel oxide, later.
2011	Australia (Western Australia)	Ravensthorpe (restart) First Quantum Minerals Ltd.	0.73 0.58 0.53	120,000 150,000 110,000	39,000	Nickel-cobalt hydroxide.
2011	Brazil (Goias)	Barro Alto Anglo American plc	1.50 1.22 1.42	9,100 9,800 63,000	36,000	Ferronickel.
2011–13	Madagascar (Moramanga)	Ambatovy (Ambatovy and Analamay deposits) Sherritt International Corp. (40%), Korea Resources Corp. (27.5%), Sumitomo Corp. (27.5%), and SNC-Lavalin Inc. (5%)	1.05 0.84 1.08	84,000 [4] 22,000 29,000	60,000	Nickel metal powder and briquettes.
2012	Burma (Thabeikkyin, Mandalay)	Tagaung Taung China Nonferrous Metals Mining Group Co., Ltd. (CNMC), Government of Burma, and Taiyuan Iron and Steel (Group) Co., Ltd. (TISCO)	2.02	40,000	22,000	Ferronickel.
2012	Papua New Guinea (Madang)	Ramu Metallurgical Group Corp. of China Ltd. consortium (85%),[5] Highlands Pacific Ltd. (8.56%), and Mineral Resources Development Co. (6.44%)	0.93 1.07 1.04	42,000 30,000 71,000	31,000	Nickel-cobalt hydroxide.
2012	Philippines (Surigao del Norte and Surigao del Sur)	Adlay-Cagdianao-Tandawa Surigao Integrated Resources Corp. (assignment from CTP Construction and Mining Corp.)	1.61 1.58	5,800 13,000	20,000	Direct shipping ore.
2012	Philippines (Zambales)	Acoje and Zambales—Stage 1 DMCI Holdings, Inc. and ENK PLC (formerly European Nickel PLC)[7]	1.04 1.03 1.25 1.03	22,000 [6] 4,200 [6] 21,000 [8] 2,200 [8]	24,500	Do.
2013	Australia (Queensland)	Lucky Break (Circular Laterite and Dingo Dam) Metallica Minerals Ltd. (50%) and Metals Finance Ltd. (50%)	0.82 0.82 0.75	590,000 48,000 490,000	730	Nickel carbonate.
2013	New Caledonia (Northern)	Koniambo (saprolite ores) Société Minière du Sud Pacifique S.A. (51%) and Xstrata Nickel (49%)	2.54 2.45 2.50	21,000 54,000 83,000	60,000	Ferronickel.
2013	Philippines (Surigao del Norte and Surigao del Sur)	Taganito mine and hydrometallurgical processing plant Mine ownership—Nickel Asia Corp. (65%), Pacific Metals Co., Ltd. (33.5%), and Sōjitsu Kabushiki-gaisha (SOJITZ) Corporation (1.5%) Hydrometallurgical processing plant ownership—Sumitomo Metal Mining Co., Ltd. (62.5%), Nickel Asia Corp. (22.5%), and Mitsui & Co., Ltd. (15%)	1.14 0.95	83,000 [9] 360 [9]	30,000	Nickel-cobalt sulfide.

See footnotes at end of table.

TABLE 13—Continued

NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

Projected year of first production	Country (state/province)	Project and company[1]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[2]	Annual production capacity (metric tons of contained nickel)	Nickel product
2014	Australia (Tasmania)	Barnes Hill, Mount Vulcan, and Scott's Hill Proto Resources & Investments Ltd.[10] and Metals Finance Ltd.	0.82	6,600	2,000	Metal.
2014	Philippines (Romblon)	Romblon (Sibuyan Island) Pelican Resources Ltd.	1.54	7,300	9,000	Direct shipping ore.
2015	Australia (Queensland)	Marlborough (Coorumburra, Slopeaway, and Whereat)[11]—Stage 1 Gladstone Pacific Nickel Ltd.	0.99 0.91 0.70	12,000 43,000 70,000	63,000	Metal.
2015	Australia (Queensland)	NORNICO-Greenvale (Bell Creek, Greenvale, Kokomo, Lucknow, and Minnamoolka deposits) Metallica Minerals Ltd.	0.96 0.77 0.70	14,000 29,000 6,000	10,000	Nickel-cobalt hydroxide.
2015	Cuba (Holguin)	Las Camariocas-Yamaguey Quality Cuba S.A.	1.32	110,000	21,000	Ferronickel.
2015	Indonesia (Sulawesi)	Mandiodo PT Antam (Persero) Tbk	2.10 1.50	5,000 [12] 28,000 [13]	12,000	Nickel pig iron.
2015	Do.	North Konawe Jilin Horoc Non-Ferrous Metal Group Co., Ltd., PT Billy Indonesia, and Government of Southeast Sulawesi	1.50	100,000	20,000	Ferronickel.
2016	Australia (Western Australia)	Mt. Thirsty Barra Resources Ltd. (50%) and Fission Energy Ltd. (50%)	0.60 0.51	17,000 15,000	9,000	Nickel-cobalt sulfide.
2016	Do.	NiWest (Eucalyptus, Hepi, Mt. Kilkenny, and Wanbanna) GME Resources Ltd.	1.04 0.99 0.96	34,000 24,000 21,000	30,000	Do.
2016	Australia (junction of the Western Australian, South Australian, and Northern Territory borders)	Wingellina Metals X Ltd.	1.00 0.97 0.97	69,000 99,000 16,000	40,000	Nickel-cobalt hydroxide.
2016	Cameroon (East Province)	Mada and Nkamouna Geovic Cameroon PLC. (60%) and National Investment Corp. (40%)	0.68 0.67 0.19 0.59 0.58	60,000 [14] 21,000 [14] 20,000 [14] 40,000 [15] 180,000 [15]	3,200	Cobalt-nickel sulfide.
2016	New Caledonia (Nakety-Bogota)	Nakety-Bogota[16] Société Gestion—Exploitation des Mines de Nickel (GEMINI S.A.), Société Minière Georges Montagnat S.A., and Société des Mines de la Tontouta (Ballande Group)	1.47 1.50	88,000 [17] 140,000 [18]	52,000	Ore.
2016	Philippines (Agusan del Norte)	Agata (includes Bolobolo-Karihatag and Agata South) Mindoro Resources Ltd.	1.00 1.16 0.95 1.18 0.80 1.11	250 [6] 540 [19] 13,000 [6] 29,000 [19] 680 [6] 1,700 [19]	7,500 14,000	Phase I, direct shipping ore. Phase 2, nickel-cobalt hydroxide.

See footnotes at end of table.

TABLE 13—Continued
NICKEL: NEW LATERITE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

Projected year of first production	Country (state/province)	Project and company[1]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[2]	Annual production capacity (metric tons of contained nickel)	Nickel product
2016	Philippines (Mindoro Oriental)	Mindoro I/ Sablayan (Buraboy, Kisluyan, and Shabo areas) Aglubang Mining Corp. (local partner) and Intex Resources ASA	0.85 0.86 0.77	17,000 210,000 91,000	53,000	Metal.
2016	Philippines (Zambales)	Acoje and Zambales—Stage 2 DMCI Holdings, Inc. and ENK PLC (formerly European Nickel PLC)[7]	1.12	30,800 [20]	24,000	Nickel-cobalt hydroxide.
2016	Tanzania (Northern/ Lake Victoria)	Dutwa (Wamangola and Ngasamo Hill) African Eagle Resources plc	0.90 0.97	60,000 [21] 38,000 [22]	32,000	Nickel-cobalt hydroxide or sulfide.
2016	Turkey (Manisa)	Caldag VTG Nikel Madencilik San. ve Tic. A.Ş., a subsidiary of OreMine Madencilik (OreMine Resources) San. ve Tic. A.Ş.	1.13	33,000	21,000	Nickel-cobalt hydroxide.

Do. Ditto.

[1] Company names reflect organizational structure as of January 31, 2012. BHP Billiton Group is a dual listed company comprising BHP Billiton Ltd. and BHP Billiton Plc. Vale Nickel is a wholly owned subsidiary of Vale S.A. (formerly Companhia Vale do Rio Doce).

[2] Gross weight, dry. "Estimated resources" are rounded to no more than two significant digits and represent measured, indicated, and (or) inferred resources depending on the project. When two or more data sets are listed, the first resource data represent measured resources; the second, indicated resources; and the third, inferred resources, unless otherwise specified.

[3] On December 19, 2008, the name of the project—Goro—was changed to Vale Inco Nouvelle-Calédonie. Vale Inco Nouvelle-Calédonie was renamed Vale Nouvelle-Calédonie in May 2010.

[4] Data represent mineral resources of only the Ambatovy deposits. Significant additional resources are associated with the Analamay deposits, northeast of the Ambatovy mine area.

[5] The Chinese consortium is owned by Metallurgical Corporation of China Ltd. (61%), Jinchuan Group Ltd. (13%), Jilin Jien Nickel Industry Co., Ltd. (13%), and Jiuquan Iron & Steel Group Co., Ltd. (13%).

[6] Limonite.

[7] In June 2010, European Nickel PLC and Rusina Mining NL merged to form ENK PLC.

[8] Zambales—laterite.

[9] Dry metric tons of limonite. Figures exclude saprolite resources.

[10] Proto Resources & Investments Ltd. was also evaluating the Waite Kauri North laterite deposit near Leonora in Western Australia.

[11] The Marlborough ores would be supplemented with ores from the mines of Société des Mines de la Tontouta and Société Miniere Georges Montagnat in New Caledonia.

[12] Measured resources of nickel in saprolite.

[13] Measured resources of nickel in limonite.

[14] Nkamouna deposit—first datum is indicated resources; second is indicated resources; and third is inferred resources.

[15] Mada deposit—first datum is indicated resources; and second is inferred resources.

[16] Ore would be shipped to Queensland for blending with ores from the Marlborough project and subsequent processing.

[17] Nakety.

[18] Bogota.

[19] Saprolite.

[20] Acoje only.

[21] Wamangola deposit inferred resource.

[22] Ngasamo Hill deposit inferred resource.

Sources: Company annual reports, presentations, and press releases; CRU International, Ltd.

TABLE 14
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

Projected year of first production[1]	Country (state/province)	Project and company[2]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[3]	Annual production capacity (metric tons of contained nickel)	Nickel product
2010–2011	Australia (Western Australia)	Lanfranchi-Deacon Panoramic Resources Ltd.	1.93	6,800	18,000	Ore.
2010–2011	Do.	Prospero Xstrata Nickel Australasia	6.39 6.42 5.03	420 470 450	10,000	Concentrate.
2010–2011	Do.	Sinclair (underground)[4] Xstrata Nickel Australasia	3.88 2.50 2.10	100 830 710	5,500	Do.
2010–2011	Canada (Ontario)	Nickel Rim South Xstrata Nickel	1.65 1.48 1.60	2,800 2,500 15,000	18,000	Do.
2010–2011	Finland (Sotkama)	Sotkama Talvivaara Mining Co. Plc	0.22	1,500	50,000	Nickel-cobalt sulfide.
2010–2011	Canada (Manitoba)	Bucko Lake (restart) CaNickel Mining Ltd.	1.45 1.52 1.34	3,700 2,800 5,500	5,000	Concentrate.
2011	Australia (Western Australia)	Spotted Quoll Underground—Stage I Western Areas NL	4.10	1,700	10,000	Do.
2012	Do.	Cosmic Boy and Diggers[5] Western Areas NL	1.46 [6] 2.40 [7] 1.00 [8]	2,100 380 10,000	7,000	Do.
2012	Canada (Quebec)	Raglan-Kikialik Xstrata Nickel	3.10	1,800	24,000	Do.
2012	Finland (Lappi)	Kevitsa First Quantum Minerals Ltd.	0.29 0.32 0.29	89,000 150,000 35,000	10,000	Do.
2012–2013	Finland (Pohiois)	Outokumpu Copper (Kylylahti mine and Luikonlahti mill) Altona Mining Ltd.[9]	0.17 0.20 0.18	620 7,500 310	450	Cobalt-nickel concentrate.
2013	Australia (Western Australia)	Radio Hill and Sholl (bacterial heap leaching) Fox Resources Ltd.	0.59	6,000	7,400	Nickel-cobalt carbonate.
2013	Canada (Ontario)	Fraser Morgan Xstrata Nickel	1.94 1.81 1.70	4,400 2,400 1,800	6,000	Ore.
2013	Do.	Hart Liberty Mines Inc.	1.40	1,500	9,000	Concentrate.
2013	Do.	Totten (plus new Clarabelle mill addition) Vale Nickel	1.33	8,400	8,200	Do.
2013	Canada (Quebec)	Nunavik (South Raglan) [Allammaq, Expo, Ivakkak, Mequillon, Mesamax, and TK deposits] Jilin Jien Nickel Industry Co., Ltd. and Goldbrook Ventures Inc.[10]	0.93 0.93 0.73	560 21,000 5,200	6,800	Do.
2013	China (Xinjiang Autonomous region/ East Tianshan)	Tula'ergen Xinjiang Hami Hexin Mining Ltd.	1.10	100,000	3,000	Do.
2013	United States (Michigan)	Eagle Kennecott Minerals Co. (Rio Tinto Group)	3.47 3.16	3,600 500	17,000	Do.

See footnotes at end of table.

TABLE 14—Continued
NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

Projected year of first production[1]	Country (state/province)	Project and company[2]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[3]	Annual production capacity (metric tons of contained nickel)	Nickel product
2014	Canada (Manitoba)	Makwa (formerly Maskwa) Mustang Minerals Corp.[11]	0.54	9,800	3,700	Concentrate.
2014	Do.	Minago Victory Nickel Inc.	0.56 0.51 0.53	11,000 43,000 15,000	11,000	Do.
2014	Canada (Sudbury)	Copper Cliff Deep Vale Nickel	NA	130,000	NA	Do.
2014	China (Gansu)	Heishan Jinchuan Group Co., Ltd.	0.60	23,000	5,000	Do.
2014	Finland (Oulu)	Kuhmo (Arola, Hietaharju, Peura-aho, Sika-aho, and Vaara) Altona Mining Ltd.[9] and Polar Mining Oy	0.55	6,000	3,000	Do.
2014	United States (Minnesota)	NorthMet PolyMet Mining Corp. and Glencore International AG	0.08 0.08	580,000 230,000	7,100	Concentrate, initially. Byproduct nickel-cobalt hydroxide, later.
2015	Australia (Western Australia)	Mt. Windarra Poseidon Nickel Ltd.	1.24 1.72	910 3,000	7,000	Concentrate.
2015	Do.	New Morning/Daybreak Western Areas NL	3.70 [12] 3.50 [12] 0.90 [13] 0.90 [13]	320 93 1,100 660	3,000	Ore.
2015	Canada (Ontario)	Onaping Depth Xstrata Nickel	2.67 3.60	15,000 1,200	10,000	Do.
2015	Russia (Amur)	Kun-Manie (Falcon, Ikensoe, Maly Krumkon, and Vodorazdelny) Amur Minerals Corp.	0.61 0.48 0.54	3,700 48,000 17,000	16,000	Concentrate.
2015	Tanzania (Kagera region)	Kabanga Barrick Gold Corp. and Xstrata Nickel	2.49 2.72 2.60	14,000 23,000 21,000	40,000	Do.
2015	Vietnam (Son La)	Ban Phuc Asian Mineral Resources Ltd. and Son La Mechanical Engineering JSC	2.68 [12] 1.94 [12] 0.59 [13] 0.56 [13]	1,700 170 13,000 7,400	6,400	Do.
2016	Australia (Western Australia)	Sherlock Bay Australasian Resources Ltd.	0.38 0.39 0.44	9,600 9,400 6,400	8,500	Bioleachate precipitate.
2016	Do.	Sholl B2 Fox Resources Ltd. and Jinchuan Group Ltd.	0.59 0.51	2,300 3,500	3,000	Do.
2016	Botswana (Selebi-Phikwe region)	Dikoloti Discovery Metals Ltd. and Japan Oil, Gas and Metals National Corp.	0.70	4,100	2,000	Nickel-cobalt sulfide.
2016	Canada (British Columbia)	Turnagain Hard Creek Nickel Corp.	0.18 0.16 0.15	59,000 430,000 560,000	24,000	Concentrate.
2016	Canada (Ontario)	Eagle's Nest-McFaulds Lake Noront Resources Ltd. and Baosteel Resources International Co., Ltd.	2.08 1.50 1.10	5,400 5,600 9,000	NA	Do.
2016	Do.	Kenbridge (open pit) Canadian Arrow Mines Ltd.	0.42	45,000	3,900	Do.

See footnotes at end of table.

TABLE 14—Continued

NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

Projected year of first production[1]	Country (state/province)	Project and company[2]	Resource grade (% nickel)	Estimated resources (thousand metric tons)[3]	Annual production capacity (metric tons of contained nickel)	Nickel product
2016	Do.	Victoria	2.20	12,500	NA	Ore.
		QuadraFNX Mining Ltd.				
2016	Canada	Dumont	0.29	190,000	30,000	Ferronickel.
	(Quebec)	Royal Nickel Corp.	0.27	1,200,000		
			0.26	700,000		
2016	Do.	Raglan-Qakimajung	4.52	2,500	11,000	Concentrate.
		Xstrata Nickel				
2016	Canada	Wellgreen	0.38	290,000	10,000	Do.
	(Yukon Territory)	Prophecy Platinum Corp. (formerly Pacific Coast Nickel)	0.69	14,000		
2016	Russia	Vuruchuaivench	0.23	17,500	NA	Metal.
	(Kola Peninsula)	MMC Norilsk Nickel-Kola MMC				
2016	Russia	Maslovsky	0.33	220,000	18,000	Do.
	(Taimyr Peninsula)	MMC Norilsk Nickel-Polar Division				
2016	South Africa	Sheba's Ridge	0.20	80,000	24,000	Do.
	(Mpumalanga and	Aquarius Platinum Ltd. (39%), Anglo Platinum	0.18	97,000		
	Limpopo)	Ltd. (35%), and Industrial Development Corp. of South Africa (26%)[14]	0.19	430,000		
2016	United States	Nokomis/ Maturi Extension	0.20 [15]	550,000	19,000	Byproduct nickel-cobalt sulfide or hydroxide.
	(Minnesota)	Birch Lake, Maturi, Spruce Road	0.21 [16]	270,000		
		Twin Metals Minnesota LLC[17] [Duluth Metals	0.17 [18]	180,000		
		Ltd. (60%) and Antofagasta PLC (40%)]	0.16 [19]	40,000		
			0.25 [20]	120,000		
			0.21 [21]	120,000		
2016	Zimbabwe	Hunters Road	0.55	36,000	2,000	Concentrate.
	(Midlands)	Bindura Nickel Corp. [Mwana Africa Holdings (Pty) Ltd.]				

Do. Ditto. NA Not available.

[1] Two years are shown for selected newly commisioned projects where the company is ramping up production.

[2] Company names reflect organizational structure as of January 31, 2012. BHP Billiton Group is a dual listed company comprising BHP Billiton Ltd. and BHP Billiton Plc. Vale Nickel is a wholly owned subsidiary of Vale S.A.

[3] Gross weight, dry. "Estimated resources" are rounded to no more than two significant digits and represent measured, indicated, and (or) inferred resources depending on the project. When two or more data sets are listed, the first resource data represent measured resources; the second, indicated resources; and the third, inferred resources, unless otherwise specified.

[4] The Sinclair deposit remains open at depth.

[5] Includes Diggers Rocks, Diggers South, Purple Haze, and Seagull resources.

[6] Diggers areas, probable ore reserves.

[7] Cosmic Boy area, indicated resources.

[8] Diggers areas, indicated resources.

[9] Altona Mining Ltd. was created when Universal Resources Ltd. merged with Vulcan Resources Ltd. in February 2010.

[10] Jilin Jien Nickel Industry Co., Ltd. and Goldbrook Ventures Inc. completed their acquisition of Canadian Royalties Inc. on January 12, 2010.

[11] Mustang Minerals Corp. was also evaluating the potential of resources at the nearby Mayville property.

[12] Massive sulfides.

[13] Disseminated sulfides.

[14] Aquarius Platinum Ltd. acquired Ridge Mining plc in July 2009 and took over management of Sheba's Ridge in August 2009.

[15] Nokomis deposit indicated resource.

[16] Nokomis deposit inferred resource.

[17] In March 2011, Twin Metals Minnesota LLC (TMM) acquired Franconia Minerals Corp., doubling the project's mineral and land assets.

[18] Birch Lake deposit indicated resource.

TABLE 14—Continued

NICKEL: NEW SULFIDE PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2016

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[19] Birch Lake deposit inferred resource.

[20] Maturi deposit resource.

[21] Spruce Road open pit resource.

Sources: Canadian Minerals Yearbook 2008, 2009; company annual reports, presentations, and press releases; CRU International, Ltd., and the International Nickel Study Group.

NIOBIUM (COLUMBIUM) AND TANTALUM

By John F. Papp

Domestic survey data and tables were prepared by Robin C. Kaiser, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, U.S. niobium apparent consumption (measured in contained niobium) was 8,210 metric tons (t), 95% more than that of 2009; U.S. tantalum apparent consumption (measured in contained tantalum) was 1,160 t, 145% more than that of 2009. No domestic mine production of niobium or tantalum ore was reported.

Legislation and Government Programs

The Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center) did not plan to dispose of niobium or tantalum materials under its fiscal year 2010 Annual Materials Plan (AMP) and to announced the fiscal 2011 plan. The DLA Strategic Materials did not sell niobium or tantalum materials in calendar year 2010. The DLA Strategic Materials' fiscal year 2011 AMP set maximum disposal goals for niobium and tantalum materials (niobium materials measured in contained niobium, and tantalum materials measured in contained tantalum) at zero (Defense Logistics Agency—Strategic Materials, 2011, p. 1). DLA Strategic Materials suspended the sale of niobium and tantalum materials to retain remaining quantities in the National Defense Stockpile inventory pending the outcome of the requirements review expected in January 2011 (Under Secretary of Defense for Acquisition, Technology and Logistics, 2011, p. 2).

Consumption

In the United States, niobium was consumed by the metallurgical industry; tantalum, by the electronics industry. Niobium masteralloys—ferroniobium and niobium-nickel alloy—were consumed to produce steel and superalloys. About 75% of world niobium consumption was used for the production of microalloyed steel (Companhia Brasileira de Metalurgia e Mineração, undated c). Tantalum was consumed to produce capacitors and superalloys. More than 70% of tantalum is consumed by the electronics industry, and most of that goes into making capacitors (Serjak and others, 2002).

Prices

The annual average price (in dollars per kilogram of contained Ta_2O_5) of tantalite peaked in 2008 at $96 and again in 2010 at $120. The price peak in 2008 resulted from high demand especially from economic development in China. In 2010, the price peak took place as markets recovered from the world financial downturn and subsequent recession.

Foreign Trade

Niobium and tantalum material exports from and imports to the United States included ferroniobium; niobium chemicals, metal, ore, and oxide; and tantalum metal and ore. In 2010, the values of foreign trade of these niobium and tantalum materials were $122 million for exports (46% greater than that of 2009) and $504 million for imports (74% greater than that of 2009).

The United States exported 281 t of niobium contained in niobium materials (44% greater than that of 2009) and imported 8,490 t of niobium contained in niobium materials (93% greater than that of 2009) (table 1). The United States exported 438 t of tantalum contained in tantalum materials (34% greater than that of 2009) and imported 1,600 t of tantalum contained in tantalum materials (100% greater than that of 2009) (table 2).

World Industry Structure

Based on a survey of its members, the Tantalum-Niobium International Study Center (TIC) reported annual niobium and tantalum raw material production (raw material production by members plus receipts of raw materials from nonmembers by producers and traders) to have been [in metric tons of contained tantalum (t-Ta)]—2005, 1,390 t-Ta; 2006, 948 t-Ta; 2007, 1,080 t-Ta; 2008, not available; and 2009, 489 t-Ta; and [in metric tons of contained niobium (t-Nb)]—2005, 44,400 t-Nb; 2006, 52,000 t-Nb; 2007, 69,500 t-Nb; 2008, 67,800 t-Nb; and 2009, 41,000 t-Nb. TIC aimed to resolve problems associated with the shipment of tantalum raw materials transported as Class 7 materials. Columbite ore, tantalite ore, and tin slag, as naturally occurring radioactive materials, are subject to national transportation regulations for such materials, which are usually based on United Nations regulations (Schwela, 2010a).

World Review

Burt and Millman (2010) described the scheme to break the linkage between mineral trade and conflict financing: effective and cost effective traceability from legitimate digger to exporter. They estimated that the Congo (Kinshasa) and Central Africa accounted for about 10% of the world's tantalum production in 2002–05. The TIC supported the ITRI Tin Supply Chain Initiative (iTSCi) pilot project that would bag and tag tantalum ore mined in Congo (Kinshasa) permitting its origin in the supply chain to be traced.

The geographic distribution of mineral production has increased for the past 150 years. Europe, along with the United States, accounted for nearly all world mineral production in the mid-19th century, but together now account for less than one-fifth of world mineral production. The world share of mineral production from the United States and Europe has been decreasing, while the share from Australia, Canada, China, the Commonwealth of Independent States, and several developing countries has been increasing. While exhaustion of resources of any mineral or metal is not likely to take place, mineral scarcity will likely become an issue in coming decades. The displacement of Western countries by developing countries as the leading mineral producers has major geopolitical implications, because Europe is dependent on foreign supplies to satisfy its industrial demand. It is of concern that markets for scarce minerals could change from equal access competitive bidding markets to markets where trade is conducted under long-term supply agreements among large corporations with significant government involvement resulting in a marked political influence on mineral supply (Kooroshy and others, 2010, p. 42, 89–93).

To address its critical materials needs, the European Union (EU) developed a raw materials initiative comprised of monitoring critical materials, including niobium and tantalum, pursuing fair and sustainable supply from global markets, fostering sustainable supply from within the EU, and boosting resource efficiency and promoting recycling (European Commission, 2011, p. 143–147, 188–193).

The European Commission (EC) identified 41 raw materials and metals (relative to other materials and metals) critical to the EU based on the geopolitical framework in which they are produced and consumed. The EC based criticality on importance to the EU economy and supply risk. Supply risk was based on environmental risk, concentration of production, recycling, and substitution. The EC was concerned that there would be inadequate supply to meet emerging-technology demand. Niobium was determined to be of high economic importance, high supply risk, and high environmental country risk. Tantalum was determined to be of high economic importance and supply risk, and low environmental country risk. Concentration of production [niobium in Brazil, tantalum in Congo (Kinshasa)] was identified as the leading contributing factor to supply risk for niobium and tantalum. The emerging technology affecting demand for tantalum was identified as microcapacitors and medical technology. The emerging technology affecting demand for niobium was identified as microcapacitors and ferroalloys. In addition to increasing demand resulting from the emerging technologies identified above, raw material and metal demand will increase as the world economy grows. China's economy was growing as was that of India, and there remain large areas of the world, like Africa, where gross domestic product is substantially less than that of other areas, like Europe, providing possibilities for future economic growth. During the past 20 years, the world economy grew at 3.8% per year until 2004 and then at 5% per year, mainly as a result of China's economic growth. Assuming growth of 3.8% per year, raw material demand in 2030 was estimated to be 2.4 times that of 2006. The EC recommended periodic critical raw material assessments; improvement of raw materials statistical information; EU policies that improved access to primary raw materials resources including land access, trade, and investment; encouraging recycling; substitution; and efficient use (European Commission, 2010a, p. 143–147 (Nb), p. 188–193; b, p. 5, 6, 12–14, 19, 23, 34–39, 43, 47).

Australia.—The government of Western Australia reported that tantalite production data were not available in 2010; 105 t of contained tantalum pentoxide (Ta_2O_5) was produced in 2009 (Government of Western Australia, Department of Mines and Petroleum, 2011, p. 21). Australia reported that, as of December 31, 2009, Joint Ore Reserves Committee (JORC)-compliant proven and probable ore reserves (as stated in company annual reports and reports to the Australian Stock Exchange) for niobium were not available; and for tantalum were 19,000 t of contained tantalum, and accessible economic-demonstrated resources for niobium were 115,000 t and for tantalum were 51,000 t (Geoscience Australia, 2010, p. 5–6).

Global Advanced Metals, formerly Talison Tantalum Ltd., operated the Wodgina and Greenbushes tantalum mines and mineral processing plants, which remained on care-and-maintenance status since December 2008 (Schwela, 2010b, p. 2). Global Advanced Metals planned to restart tantalum production when global inventory of tantalum is balanced (Global Advanced Metals, 2010).

Galaxy Resources Ltd. planned to ship tantalum concentrate from Mount Cattlin, Western Australia, near the town of Ravensthorpe, to Global Advanced Metals Pty. Ltd., starting in 2011 at the rate of 90,000 kg of contained Ta_2O_5 per year for the next 5 years (Galaxy Resources Ltd., 2010b, p. 8, 10). Galaxy reported proved reserves of 2.683 Mt containing 135 parts per million (ppm) Ta_2O_5 and probable reserves of 8.684 Mt containing 151 ppm Ta_2O_5 at a cutoff grade of 0.4% LiO_2 as of March 31, 2010 (Galaxy Resources Ltd., 2010a, p. 7).

Alkane Resources LTD's (2011, p. 5–8) (Dubbo Zirconia Project, Toongi deposit, New South Wales), Artemis Resources Ltd. (2010, p. 10) (Buchanan's Creek/Grant's Gully tenements south of Georgetown, Queensland), Capital Mining Ltd. (2011, p. 20–21) (Narraburra prospect about 12 kilometers (km) northeast of Temora, New South Wales) explored for niobium and (or) tantalum.

Brazil.—The National Department of Mineral Production (DNPM) reported that Anglo American Brazil Ltd. (a subsidiary of Anglo Americal plc) and Companhia Brasileira de Metalurgia e Mineração (CBMM) produced niobium, and Mineração Taboca produced tantalum. Pereira (2011) reported Brazilian niobium mine production of 165,723 t-Nb_2O_5 (tons of contained niobium pentoxide) from reserves of 4,499,106 t-Nb_2O_5 in 2009, from which Brazil produced 88,920 t-Nb_2O_5 contained in concentrate, 34,746 t-Nb contained in ferroniobium, and 2,333 t-Nb_2O_5. Pontes (2011) reported Brazilian tantalum mine production of 218 t-Ta_2O_5 (tons of contained tantalum pentoxide) contained in concentrate from reserves of 87,782 t-Ta_2O_5 in 2009.

Anglo American Brazil Ltd. (a subsidiary of Anglo American plc) mined pyrochlore from a carbonatite deposit. Catalão Mine (47°48' W, 18°08' S) is comprised of three open pit mines and a processing facility. Anglo reported that Catalão mined 1,209,400 t of ore and processed 909,300 t of ore containing 6.6 kilograms of niobium per metric ton of ore to produce 4,000 t of contained niobium in 2010. JORC-compliant proved and probable reserves in 2010 were 5.1 Mt at 1.07% Nb_2O_5 containing 55,000 t of niobium (Anglo American plc, 2011, p. 191, 198).

CBMM mined niobium ore from the Barreiro carbonatite complex (19°40' S, 46°57' W) and beneficiated the ore at the mine site by selectively extracting the pyrochlore minerals from which niobium oxide is separated (Filho and others, 2009). The deposit contained 440 Mt of ore reserves at an average grade of 2.5% to 3% Nb_2O_5 that could be mined by open pit methods (Riffel, undated). CBMM produced ferroniobium, nickel-niobium, niobium metal, and high-purity ferroniobium, and had production capacities of 90,000 t/yr of ferroniobium, 3,000 t/yr of high-purity ferroniobium and nickel-niobium, and 210 t/yr of niobium metal (Companhia Brasileira de Metalurgia e Mineração, undated a, b).

Cia. Estanho Minas Brasil (Mibra) owned by Companhia Industrial Fluminense (CIF), an AMG Advanced Metallurgical Group N.V. company, was the leading world producer of tantalum, with an annual production capacity of 136 t of Ta_2O_5 contained in concentrate at Volta Grande Mine (21°05' S, 44°35' W). Mibra planned to increase production capacity to 227 t/yr of Ta_2O_5 contained in concentrate. CIF reported NI 43–101-compliant reserves of 6.32 Mt of compact pegmatite grading 375 g/t Ta_2O_5 and 92 g/t Nb_2O_5 in 2008 (Schwela, 2010b, p. 2–6).

Mineração Taboca S.A. mined columbite at the Pitinga Mine (0°47'01" N, 60°04'43" W). Taboca produced a ferroniobiumtantalum alloy containing 45% niobium, 4.5% tantalum, and 25% iron that was sold for niobium and tantalum oxide production (Mineração Taboca S/A, undated a, b).

Canada.—Canada reported niobium mine production of 4,419 t of contained Nb_2O_5 and no tantalum mine production in 2010 compared with 4,169 t of contained Nb_2O_5 and 29 t of contained Ta_2O_5 in 2009. Niobium was produced in Quebec, and tantalum, in Manitoba (Natural Resources Canada, 2011a, b).

Avalon Rare Metals Inc. (Toronto, Ontario) prospected for niobium and tantalum at its Thor Lake (about 62°06'20" N, 112°36' W) property. Avalon completed a prefeasibility study and undertook a bankable feasibility study. Avalon reported Thor Lake probable reserves of 12.01 Mt at 0.41% Nb_2O_5 and 0.041% Ta_2O_5. Avalon planned to produce 1,700 t/yr of Nb_2O_5 and 100 t/yr of Ta_2O_5 (Avalon Rare Metals Inc., 2010, p. 3–7).

Commerce Resources Corp. (Vancouver, British Columbia) prospected for niobium and (or) tantalum at the Blue River (east of Quesnel, British Columbia), Carbo (northeast of Prince George, British Columbia), and Eldor (south of Kuujjuaq, Quebec) properties that host carbonatite deposits. Commerce Resources reported NI 43–101-compliant Blue River (52°19' N, 119°10' W), comprising Fir, Verity, and Upper Fir deposits, indicated resources of 36.35 Mt containing 7,090 t of Ta_2O_5 and 61,650 t of Nb_2O_5 (Commerce Resources Corp., 2011, p. 4-1, 17-1–17-21).

IAMGOLD Corp. (Toronto, Ontario) mined niobium contained in pyrochlore mineral from the Saint-Honoré carbonatite deposit at the Niobec Mine (about 48°32' N, 71°09' W). Niobec mill production capacity was 4,500 t/yr of niobium. The mill produced concentrate from which Niobec produced Nb_2O_5 that was then converted to standard grade (66% niobium) ferroniobium by aluminothermic reduction. IAMGOLD completed a paste backfill plant and mill expansion. IAMGOLD reported that niobium mine production in 2010 was 4,400 t of contained Nb compared with 4,100 t in 2009 and 4,400 t in 2008. IAMGOLD reported 45.716 Mt of proven plus probable ore reserves containing 243,800 t of Nb_2O_5 (average ore grade of 0.53% Nb_2O_5). In 2010, IAMGOLD mined 1.792 Mt of ore, milled 1.864 Mt of ore, and produced 4,400 t of Nb at the Niobec Mine (IAMGOLD Corp., 2011, p. 2, 16).

MDN Inc. (2011, p. 14) completed a feasibility study in March 2011 for its Crevier niobium project (49°30′ N, 72°49′ W). The Crevier project reported measured plus indicated resources of 25.369 Mt containing 0.196% Nb_2O_5 and 234 ppm Ta_2O_5. MDN planned to start Crevier Mine construction in 2013, with possible production of 4,000 metric tons per day from an open pit. MDN planned to use conventional flotation circuit to produce primary concentrate followed by niobium and tantalum oxide separation using acid leaching (Schwela, 2010b, p. 9).

Tantalum Mining Corp. of Canada Ltd. (50°26' N, 95°27' W) suspended mine production at its tantalite mine in Manitoba in April 2009 and operated on inventory through November (Cabot Corp., 2011, p. 6).

Niocan Inc. (2011, p. 2) explored for niobium minerals at its Oka property near Oka, Quebec. Niocan reported 10.63 Mt of measured plus indicated resources of 0.68% Nb_2O_5 as of December 2009.

Nuinsco Resources Ltd. (2011, p. 4) (Prairie Lake, Ontario), Quest Rare Minerals Ltd. (2011) (Misery Lake and Strange Lake, on the Quebec-Labrador border), Sarissa Resources Inc. (2010, p. 58) [Nemegosenda niobium property (48°00′ N, 83°06′ W), Ontario], and Taseko Mines Ltd. (2011, p. 5) (Aley prospect, British Columbia) explored for niobium minerals.

China.—The leading tantalum mining areas were at Yichun, Jiangxi Province, and Nanping, Fujian Province. TiChun Tantalum & Niobium Mine (27°38'58.10" N, 114°31'4.06" E) produced tantalum and niobium concentrate.

King-Tan Tantalum Industry Co. Ltd. in Shishi Industrial Zone, Yifeng County, Jiangxi Province, produced niobium and tantalum products (King-Tan Tantalum Industry Co. Ltd., undated). Ningxia Non-ferrous Metals Smeltery (a state-owned enterprise) produced niobium and tantalum products (Ningxia Non-ferrous Metals Import & Export Corp., undated).

Congo (Kinshasa).—Katanga, Kivu, Maniema, and Orientale Provinces in the eastern part of Congo (Kinshasa) host columbite-tantalite (coltan) deposits (Fetherston, 2004, p. 71). Shamika Resources Inc. (Montreal, Quebec, Canada) explored for tantalum and niobium through Shamika Congo Kalehe SPRL (Schwela, 2010b, p. 11). Katanga Province reported coltan mineral exports of 159.72 t in 2010. The leading exporter was Mining Mineral Resources Sprl (Kitumba, 2011).

Egypt.—Tantalum Egypt JSC [Gippsland Ltd. (Claremont, Australia) and the Government of Egypt] planned to mine tantalite from the Abu Dabbab (25°20'59.42" N, 34°13'30.07" E) and Nuweibi (25°12'3.09" N, 34°29'56.15" E) deposits, starting with Abu Dabbab in 2013 (Schwela, 2010b, p. 7). Gippsland reported proven reserves Abu Dabbab were 15.20 Mt at 260 g/t Ta_2O_5 and probable reserves 15.04 Mt at 250 g/t Ta_2O_5. H.C. Stark Group GmbH (Goslar, Germany) committed to buy 300,000 kilograms per year of contained Ta_2O_5 for the first 10 years of the mine operation (Gippsland Ltd., 2011, p. 8–9, 16).

Germany.—Germany, as an industrialized, economically developed nation, grew through technological innovation.

German industry relied on imported raw materials supply, which emerging technologies would convert into high-tech, cutting edge products. Wage cost increased more slowly than raw materials cost that accounted for 43% of manufacturing sector cost in 2006 (compared to 1.8% for energy, 22.7% for personnel, and 32.5% for other). Niobium and tantalum were among 15 vulnerable raw materials identified as needed by the German manufacturing industry as a result of the analysis of the impact of 32 emerging technologies. German economic development depends on secure supply of stably priced raw materials (Angerer 2009, p. 1, 2, 9–13).

Greenland.—Ram Resources Ltd. (Perth, Australia) explored the Motzfeldt area (near 61°15′ N, 46° W). More exploration was required to define JORC-compliant resources (Ram Resources Ltd., 2010a, p. 6; Schwela, 2010b, p. 10).

Malawi.—Globe Metals & Mining Ltd. (Australia) planned to bring the Kanyika joint-venture niobium mining project with tantalum and uranium byproducts into production in 2013. Globe planned to produce about 3,000 t/yr of ferroniobium and 192 t/yr of Ta_2O_5. Globe planned to extract oxides of niobium, tantalum, and uranium via solvent extraction and to make ferroniobium from the Nb_2O_5 (Mining Journal, 2010, p. 8). Globe reported updated JORC-compliant (measured plus indicated plus inferred) resources for the Kanyika niobium project (about 12°38′ S, 33°38′ E) of 60 Mt containing 174,000 t of Nb_2O_5 (0.29% average grade) and 8,400 t of Ta_2O_5 (0.014% average grade), at a cutoff grade of 0.15% Nb_2O_5. Globe planned to prepare a preliminary mine design (Globe Metals & Mining Ltd., 2010, p. 4–8).

Mozambique.—Noventa Ltd. (St. Helier, United Kingdom) stopped production at the Marropino Mine (16°30’ 40” S, 37°54’ 10” E) in January and planned to restart production in 2011 and upgrade its processing plant. Noventa planned to produce about 300 t/yr Ta_2O_5 contained in concentrate (Schwela, 2010b, p. 2; Noventa Ltd., 2011, p. 6, 9).

Pacific Wildcat Resources Corp. (Canada), a mineral exploration company, acquired Tantalum Mineracao e Prospeccas Ltda., which held licenses for tantalum exploration in the Alto Lingonha belt, Zambezi Province (about 15°45′10” S, 33°15′10” E) near the Muiane Mine, a historical tantalum producer. Pacific also purchased a tantalum treatment plant, which it started to commission and planned to use to conduct metallurgical test work (Pacific Wildcat Resources Corp., 2011, p. 3).

Saudi Arabia.—Tertiary Minerals plc planned to evaluate the feasibility of developing the Ghurayyah tantalum-niobium rare-earth deposit subject to receiving a new exploration license that it applied for in 2007. However, there had been no change to the status of its license (Tertiary Minerals plc, 2010, p. 3, 8).

Current research and technology.—Fife (2010) described how tantalum and other elements heavier than iron are made when heavy stars (stars with mass greater than the Chandrasekhar limit) collapse, resulting in a supernova explosion that disperses many heavy elements and leaves a neutron star.

Peries (2010, p. 8–9) reported that niobium is a potential short-term substitute for vanadium in high-strength low-alloy steel (HSLA). Like vanadium, niobium is used to increase the yield strength of steel, albeit by a different physical process. Vanadium and niobium provide grain refinement and precipitation hardening; however, they affect other metallurgical characteristics differently. Historical performance suggested that niobium could substitute for about 20% to 25% of vanadium used in HSLA steel.

Niobium contributes to solid solution strengthening, strengthening through carbide formation, and to precipitation hardening in nickel-based superalloys such as alloys 625, 706, and 718 (Patel and Smith, undated).

Gilman (2010) reported that tantalum is used in sputtering targets to make thin films on integrated circuits. Tantalum forms a protective oxide that is the basis for its application in electrolytic capacitors. In thermal ink-jet printer heads, a tantalum anticavitation film is used to protect the device from the ink. In integrated circuits that use copper metallization, a thin film of tantalum and tantalum nitride is formed to chemically isolate the copper. Copper metallization is also used in flat panel liquid crystal display panels.

Gillesberg and Gambale (2010) reported that a thin layer of tantalum metal alloy extended the operating life of many parts in the highly chemically aggressive conditions found in the sulfur-iodine water-splitting cycle, a leading candidate for thermochemical hydrogen production.

Freeman and others (2010) compared the alternating and direct current characteristics of recently developed polymer tantalum capacitors with those of traditional wet tantalum capacitors. The historical development of tantalum capacitor anodes has been from wet anodes to manganese oxide anodes to various polymer anodes. The new polymer characterized by Freeman reversed the trend of decreasing operating voltage while retaining low equivalent series resistance and high volumetric efficiency.

Shlyakhov and others (2010) described the production of niobium-titanium and niobium-tin alloy for use in superconducting magnets. The magnets were for use in the International Thermonuclear Experimental Reactor, an internationally sponsored tokamak nuclear fusion reactor.

Outlook

Niobium.—The principal use for niobium was as an additive in steelmaking, mostly in the manufacture of microalloyed steels. The production of high-strength low-alloy steel was the leading use for niobium, and the trend for niobium consumption, domestically and globally, was expected to continue to closely follow that of steel production, as the steel industry is estimated to account for as much as 90% of niobium consumption. (Additional information about the steel industry can be found in the Iron and Steel chapter of the USGS Minerals Yearbook, volume I, Metals and Minerals.) Consumption of niobium, however, does not mirror trends in overall steel production, as only 10% of steel products contain niobium. The leading nonsteel use of niobium was in superalloys for, among other applications, aircraft engines.

The long-term growth of niobium use was interrupted by the economic downturn of 2008–09. Niobium is used in high-strength low-alloy steels consumed by automobile, construction, and pipeline industries. Greater demand for natural gas was expected to result in increased demand for pipeline steel. The sharp fall in demand for automobiles and in construction that started in 2008 was part of the current economic cycle. Recovery of these markets was expected to revive demand for niobium. It was reported that globally, the unit consumption of niobium per ton of steel produced was 55 to 60 g/t, and that of highly economically developed countries was 100 g/t and that of China was 40 g/t, suggesting significant potential for niobium consumption growth as the Chinese economy continues to develop (Roskill Information Services Ltd., 2009a, p. 124–125).

Tantalum.—Consumers relied heavily on tantalum inventories and large quantities of highly contentious and politically sensitive, low-cost columbite-tantalite from Congo (Kinshasa) that appeared to have displaced producers in the conventional supply chain, while an estimated 40% of tantalum mine production capacity was put on care-and-maintenance status in 2008 and 2009, including mines in Australia, Canada, and Mozambique. The mainstream industry sought a way to exclude illegal columbite-tantalite from the supply chain. It was thought that a ban on such material by the United States and the EU was possible. New production projects in Canada, Egypt, and Saudi Arabia offered the possibility that new mines could be brought into production between 2011 and 2013. It was anticipated that as the global economy recovered, so too would demand for tantalum (Roskill Information Services Ltd., 2009b, p. 21–23).

In the midst of consumer industry concern over a possible tantalum shortage that could result from world economic recovery and demand exceeding mine production capacity development, Zogbi (2010) estimated 2009 world tantalum mine production capacity, excluding Australia and Mozambique, to have been 727 t/yr of tantalum (equivalent to 845 t/yr of Ta_2O_5, 1,031 t/yr of tantalite) and recycling production to be 544 t/yr of tantalum (equivalent to 633 t/yr of Ta_2O_5, 772 t/yr of tantalite). Australian production capacity was estimated to be 854 t/yr of tantalum (equivalent to 993 t/yr of Ta_2O_5, 1,211 t/yr of tantalite) (Talison Minerals Pty. Ltd., 2007). Mozambique production capacity was estimated to be 83 t/yr of tantalum (equivalent to 96 t/yr of Ta_2O_5, 117 t/yr of tantalite) (Noventa Ltd., 2010, p. 12). Based on these estimates, 2009 world tantalum production capacity was 3,589 t/yr tantalum while projected 2009 demand was 2,460 t of tantalum based on 4% annual growth rate from 2006—enough production capacity to meet demand even with Australian production closed. World 2013 projected demand was 2,900 t of tantalum, an amount that could be met from 2009 mine and recycling production capacity.

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TABLE 1

SALIENT NIOBIUM STATISTICS[1]

		2006	2007	2008	2009	2010^e
United States:						
Government stockpile releases, Nb content[2, 3]	metric tons	156	--	--	--	--
Exports, Nb content[4]	do.	561	1,101	781	195	281
Imports for consumption:						
Mineral concentrates, Nb content	do.	120	109	134	41	5
Niobium metal, gross weight[5]	do.	1,450	864	1,130	699	1,380
Niobium oxide, Nb content^e	do.	760	744	852	742	824
Ferroniobium, Nb content^e	do.	8,150	8,400	7,120	2,920	6,280
Reported consumption, Nb content						
Raw materials	do.	W	W	W	W	W
Ferroniobium and nickel niobium^e	do.	5,050	6,510	5,380	4,350	5,590
Apparent consumption, Nb content	do.	10,100	9,020	8,450	4,210	8,210
Value:[6]						
Niobium ores and concentrates (gross weight)	dollars per kilogram	13.71	22.55	26.70	59.86	19.84
Niobium oxide (gross weight)	do.	14.07	17.64	25.65	27.30	30.32
Ferroniobium (gross weight)	do.	9.13	13.88	21.29	23.59	24.01
World, production of niobium-tantalum concentrates, Nb content	metric tons	52,800	62,000	63,000	62,800 ^{r}	62,900

^{e}Estimated. ^{r}Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits, except values.

[2] Release is the decrease of uncommitted inventory relative to the previous calendar year.

[3] To estimate Nb content, it was assumed that natural tantalum and synthetic tantalum-niobium ores and concentrates are 16% niobium pentoxide (Nb_2O_5); niobium ores and concentrates are 30% Nb_2O_5; and Nb_2O_5 is 69.9% Nb.

[4] Includes natural and synthetic niobium ore and concentrates, niobium oxide, niobium ferroalloy, and unwrought niobium metal and alloys.

[5] Includes niobium and articles made of niobium.

[6] Mass-weighted average value of imported plus exported materials.

TABLE 2

SALIENT TANTALUM STATISTICS[1]

		2006	2007	2008	2009	2010^e
United States:						
Government stockpile releases,[2] Ta content[3]	metric tons	289	--	--	--	--
Exports:						
Tantalum ores and concentrates,[4] Ta content	do.	247	146	96	94	58
Tantalum metal, gross weight	do.	590	207	390	138	246
Tantalum and tantalum alloy powder, gross weight	do.	112	158	176	94	134
Imports for consumption:						
Mineral ores and concentrates, Ta content	do.	322	294	357	109	9
Tantalum metal and tantalum-bearing alloys,[5] gross weight	do.	835	861	934	689	1,590
Reported consumption, raw materials Ta content	do.	W	W	W	W	W
Apparent consumption, Ta content	do.	498	644	629	473	1,160
Price, tantalite,[6] Ta_2O_5 content	dollars per kilogram	72	82 ^{r}	96 ^{r}	89 ^{r}	120
Value,[7] tantalum ores and concentrates, gross weight	do.	33	43	49	30 ^{r}	32
World, production of niobium-tantalum concentrates, Ta content	metric tons	859 ^{r}	995 ^{r}	1,270 ^{r}	764 ^{r}	682

^{e}Estimated. ^{r}Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Release is the decrease in uncommitted inventory relative to the previous calendar year.

[3] To estimate Ta content, it was, assumed that natural niobium and synthetic niobium-tantalum ores and concentrates are 32% Ta_2O_5, tantalum ores and concentrates are 37% Ta_2O_5, and Ta_2O_5 is 81.9% tantalum.

[4] Includes natural and synthetic tantalum ore and concentrates.

[5] Includes unwrought powders, unwrought alloys and metals, waste and scrap, and wrought alloys and metal.

[6] Average annual price per Ta_2O_5 content as reported in Ryan's Notes.

[7] Mass-weighted average value of imported plus exported materials.

TABLE 3

REPORTED CONSUMPTION, BY END USE, INDUSTRY STOCKS OF FERRONIOBIUM AND NICKEL NIOBIUM AND GOVERNMENT STOCKS BY MATERIAL IN THE UNITED STATES[1]

(Metric tons of niobium and tantalum content)

	2009	2010
End use:		
Steel:		
Carbon	970	1,630
Stainless and heat-resisting	551	727
Full alloy	(2)	(2)
High-strength low-alloy	651	739
Electric	(2)	(2)
Tool	(2)	(2)
Unspecified	1,030	1,070
Total	3,200	4,160
Superalloys	1,130	1,400
Alloys (excluding steels and superalloys)	21	24
Miscellaneous and unspecified	--	--
Grand total	4,350	5,590
Stocks, December 31:		
Consumer	322 r	813
Producer[3]	W	W
Total	322 r	813
National Defense Stockpile, total uncommitted inventory by material:		
Niobium metal ingots	10.0	10.0
Tantalum carbide powder	1.72	1.72

r Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Included with "Steel, unspecified."

[3] Ferroniobium only.

TABLE 4
U.S. FOREIGN TRADE IN NIOBIUM AND TANTALUM METAL AND ALLOYS, BY CLAS[1]

HTS code[2]	Class	2009 Gross mass (kilograms)	2009 Value (thousands)	2010 Gross mass (kilograms)	2010 Value (thousands)	Principal destinations and sources in 2010 (gross mass in kilograms and values in thousand dollars)
	Exports:					
	Niobium:					
2615.90.6030	Ores and concentrates	17,000	$954	24,900	$228	Germany 18,100, $25; United Kingdom 4,960, $78; India 1,700, $115; China 33, $6; Italy 31, $4.
7202.93.0000	Ferroniobium	240,000	2,740	395,000	4,190	Canada 371,000, $3,930; Mexico 15,500, $170; Philippines 4,530, $50; Peru 2,770, $30; Colombia 233, $8.
	Tantalum:					
2615.90.3000	Synthetic concentrates	158,000	796	22,800	214	South Africa 16,500, $152; Ireland 4,910, $48; United Kingdom 1,120, $10; Japan 357, $3.
2615.90.6060	Ores and concentrates	160,000	2,110	149,000	2,880	Brazil 72,300, $487; Germany 32,100, $1,000; China 18,600, $78; Netherlands 17,200, $462, Hong Kong 8,680, $840; United Kingdom 48, $8; Malaysia 25, $8.
8103.20.0030	Unwrought, powders	93,800	40,200	134,000	57,400	Mexico 64,700, $28,000; Germany 34,400, $16,300; Israel 18,000, $8,080; Austria 12,700, $2,430; Portugal 2,050, $1,130; Japan 1,120, $834; China 806, $442; Thailand 12, $80; Malaysia 25, $9.
8103.20.0090	Unwrought, alloys and metal	6,760	1,030	15,400	2,730	Germany 11,900, $1,950; Malaysia 2,090, $492; Taiwan 595, $114; India 184, $66; Mexico 175, $8; Canada 57, $11; Australia 27, $8; Singapore 24, $26; Japan 13, $8; Republic of Korea 300, $24; Italy 6, $4; France 3, $4; Brazil 1, $4.
8103.30.0000	Waste and scrap	78,700 r	8,930	165,000	18,800	Hong Kong 64,440, $6,080; United Kingdom 25,800, $4,290; Japan 25,600, $2,570; Germany 15,000, $2,500; Kazakhstan 11,500, $467; Austria 7,980, $1,280; Canada 6,020, $557; Brazil 3,670, $415; Malaysia 2,840, $339.
8103.90.0000	Wrought	52,200	26,900	65,200	35,900	Mexico 28,900, $16,600; Germany 19,500, $8,670; Japan 6,750, $3,630; Republic of Korea 1,860, $1,630; Czech Republic 1,160, $844; Dominican Republic 1,080, $644; United Kingdom 947, $371; Malaysia 885, $525; France 867, $504; Israel 852, $724; Canada 667, $360; China 495, $597; Thailand 291, $173; Sweden 201, $88.
	Total	XX	83,600	XX	122,000	
	Imports for consumption:					
	Niobium:					
2615.90.6030	Ores and concentrates	4,960	360	11,600	494	China 9,430, $471; Japan 2,130, $23.
2825.90.1500	Oxide	1,060,000	29,000	1,180,000	35,800	Brazil 1,010,000, $28,300; China 58,600, $2,580; Russia 56,400, $1,580; Germany 56,300, $3,260; Japan 50, $4.
	Ferroniobium:					
7202.93.4000	Silicon < 0.4%	151,000	5,080	444,000	14,900	Brazil 336,000, $10,800; United Kingdom 80,400, $2,760; Germany 28,400, $1,280.
7202.93.8000	Other	4,340,000	104,000	9,210,000	222,000	Brazil 7,940,000, $190,000; Canada 1,260,000, $31,800; Germany 10,200, $338; France 3, $94.
	Total	4,490,000	109,000	9,660,000	237,000	
8112.92.4000	Unwrought powders[3]	699,000	24,100	1,380,000	56,900	Brazil 1,290,000, $50,100; Estonia 45,700, $3,770; Germany 35,000, $1,940; Japan 5,090, $255; China 4,230, $685; Finland 144, $213; Thailand 82, $136; Hong Kong, 25, $25; Austria 13, $29.
	Tantalum:					
2615.90.3000	Synthetic concentrates	546	27	--	--	XX.
2615.90.6060	Ores and concentrates	356,000	13,500	19,800	2,520	Brazil 11,000, $2,150; Mozambique 8,350, $270; China 255, $88; Canada 255, $5.
8103.20.0030	Unwrought powders	139,000	39,500	207,000	60,900	Thailand 73,400; $20,400; China 64,000, $18,700; Germany 39,300, $9,160; Japan 28,400, $12,000; Portugal 915, $401; Georgia 378, $153; United Kingdom 990, $138; India 130, $3; Mexico 35, $14.
8103.20.0090	Unwrought, alloys and metal	138,000	29,600	193,000	36,800	Kazakhstan 73,800, $12,600; China 49,800, $12,000; Germany 23,300, $4,580; Thailand 18,000, $4,400; United Kingdom 12,340, $1,620.
8103.30.0000	Waste and scrap	335,000	23,800	1,070,000	42,000	Russia 320,000, $2,540; Germany 230,000, $11,100; Mexico 141,000, $6,840; Estonia 64,500, $3,490; China 62,300, $5,480; Israel 41,600, $784; Taiwan 39,100, $483; Japan 35,400, $2,360; Austria 28,200, $1,820; United Kingdom 24,900, $2,400; Indonesia 15,000, $105; Czech Republic 17,100, $349; Singapore 9,880, $782; Hong Kong 9,620, $772; Kazakhstan 28,300, $489; France 5,050, $66; Austria 5,230, $2,400; Italy 4,750, $98.
8103.90.0000	Wrought	75,600	20,800	114,000	31,500	China 67,100, $19,400; Kazakhstan 28,300, $6,180; France 4,370, $962; Germany 2,600, $1,360; Republic of Korea, 2,260, $331; Belgium 1,410, $118; Israel 1,010, $129; Hong Kong 394, $47.
	Total	XX	289,000	XX	504,000	

r Revised. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

TABLE 4—Continued

U.S. FOREIGN TRADE IN NIOBIUM AND TANTALUM METAL AND ALLOYS, BY CLAS[1]

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[3] Niobium waste and scrap is included in 8112.92.0600 along with other materials. Niobium other than unwrought; waste and scrap; and powders is included in 8112.99.9000 along with other materials.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 5

U.S IMPORTS FOR CONSUMPTION OF TANTALUM ORES AND CONCENTRATES, BY COUNTRY[1]

	2009		2010	
Country	Gross mass (kilograms)	Value (thousands)	Gross mass (kilograms)	Value (thousands)
Australia	65,000	$3,260	--	--
Brazil	--	--	11,000	$2,150
Canada	116,000	4,760	255	5
China	855	56	255	88
Mozambique	174,000	5,470	8,350	270
United Kingdom	23	4	--	--
Total	356,000	13,500	19,800	2,520

--Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 6

NIOBIUM AND TANTALUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY[1,2]

(Metric tons)

Country[5]	Gross mass[3]					Niobium content[4]					Tantalum content[4]				
	2006	2007	2008	2009	2010[e]	2006	2007	2008	2009	2010[e]	2006	2007	2008	2009	2010[e]
Australia, columbite-tantalite[6]	2,140 [e]	1,630 [e]	2,060 [e]	318 [7]	--	--	--	--	--	--	478	441	557	81 [7]	--
Brazil:															
Nb minerals[8, 9]	206,550	245,766	246,000 [e]	247,000 [e]	245,000	48,129	57,267	58,000 [e]	58,000 [e]	58,000	--	--	--	--	--
Ta minerals[e, 6, 10]	645	650	650	650	650	--	--	--	--	--	176 [7]	180	180	180	180
Burundi	16	52	84	84 [e]	84	3	10	16	16 [e]	16	3	9	16	16	16
Canada:															
Nb minerals[9]	12,500 [e]	12,900 [e]	13,150	12,900	13,200	4,177 [r]	4,337	4,383	4,330	4,419 [7]	--	--	--	--	--
Ta minerals[6, 10]	249	201	150	110	--	--	--	--	--	--	56	45	40	25	--
Congo (Kinshasa):															
Columbite-tantalite[e, 11]	52 [7]	267 [7]	509 [r, 7]	490 [r, 7]	510	12	61	120 [r]	110 [r]	120	14	71	140 [r]	130 [r]	140
Nb minerals	--	--	119 [r]	44 [e]	--	--	--	-- [r, e]	22 [r, e]	--	--	--	--	--	--
Ethiopia, tantalite	109	117	183 [r]	206 [r]	210	11	12	18 [r]	21 [r]	21	49 [r]	53 [r]	83 [r]	93 [r]	95
Mozambique[e]	95 [7]	196 [7]	396 [7]	405 [7]	430	7	14	28	29	30	27	56	110	113	120
Nigeria, columbite-tantalite[e]	900	450	500	450	450	387 [7]	180 [7]	194 [7]	190 [r]	190	10	20	25	20	20
Rwanda	188	490	490 [e]	430 [e]	450	59	150	150	130	140	46	120	120 [e]	104 [e]	110
Somalia[e, 12]	--	--	11	7	--	--	--	2	2	--	--	--	3	2	--
Uganda[e]	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)	(13)
Zimbabwe[e]	NA	--	--	--	--	--	--	--	--	--	NA	--	--	--	--
Total	223,000	263,000	264,000	263,000	261,000	52,800	62,000	63,000	62,800 [r]	62,900	859 [r]	995 [r]	1,270 [r]	764 [r]	682

[e]Estimated. [r]Revised. NA Not available. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes production of columbium and tantalum contained in tin ores and slags. Table includes data available through July 5, 2011.

[3] Gross mass is mass of concentrate before metal is extracted.

[4] Content is mass of metal produced. Nb_2O_5 is 69.904% niobium; Ta_2O_5 is 81.897% tantalum.

[5] In addition to the countries listed, Bolivia, China, French Guiana, Kazakhstan, and Russia also produce, or are thought to produce, niobium and tantalum mineral concentrates, but available information is inadequate to make reliable estimates of output levels.

[6] Tantalum production reported in Ta_2O_5 converted to tantalum content. Gross mass is concentrate assumed to be one-third Ta_2O_5.

[7] Reported figure.

[8] Niobium concentrate production reported in Nb_2O_5 content converted to niobium content. Gross mass is concentrate assumed to be one-third Nb_2O_5.

[9] Includes columbite and pyrochlore.

[10] Includes djalmaite and tantalite.

[11] Reported data includes the North and South Kivu Provinces.

[12] From August 2008 to April 2009, 18 metric tons of columbite-tantalite was reportedly produced in Somalia. It is unclear if production continued after early April 2009.

[13] Less than ½ unit.

TABLE 7
FERRONIOBIUM (FERROCOLUMBIUM): WORLD PRODUCTION, BY COUNTRY[1]

(Metric tons, Nb content)

Country[2]	2006	2007	2008	2009[e]	2010
Brazil	27,434	34,612	35,534	22,932 [3]	23,100
Canada	4,157	4,337	4,385	4,620	4,620
Russia[e]	--	80	80	79	80
United States	NA	NA	NA	NA	NA
Total	31,600	39,000	40,000	27,600	27,800

[e] Estimated; estimated data are rounded to no more than three significant digits; may not add to totals shown. [r] Revised. NA Not available. -- Zero.

[1] Table includes data available through July 15, 2011.

[2] In addition to the countries listed, Austria, China, and Germany are thought to have produced ferroniobium (ferrocolumbium), but production information is inadequate for the formulation of estimates of output levels.

[3] Reported figure.

NITROGEN

By Lori E. Apodaca

The world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, U.S. ammonia production contained 8.29 million metric tons (Mt) of nitrogen, about an 8% increase from production in 2009, and apparent consumption increased by about 12% from that in 2009. Exports of ammonia doubled from those in 2009, and imports increased by about 22% compared with those of 2009. Most of the imports in 2009 were from Canada, Trinidad and Tobago, and Ukraine. About 86% of the domestically produced ammonia consumed in the United States was used in fertilizer applications. Global ammonia production in 2010, which was estimated to contain 131 Mt of nitrogen, was higher than that in 2009. China, India, Russia, and the United States were the leading producers, together accounting for about 54% of the total.

Legislation and Government Programs

In accordance with a January 2009 Clean Water Act determination and a consent decree with Florida Wildlife Federation to settle a 2008 lawsuit, the U.S. Environmental Protection Agency (EPA) proposed numeric water-quality standards for lakes and flowing waters in Florida in January and established final standards in November (U.S. Environment Protection Agency, 2010, p. 75805–75806). Implementation of the standards for inland water bodies was delayed for 15 months from November in order to give agencies and organizations the opportunity to review the standards and develop flexible strategies for implementation. However, in December, The Fertilizer Institute (TFI) filed a legal challenge to EPA's rule to establish numeric nutrient criteria for nitrogen and phosphorous for waters in the State of Florida. TFI stated that the rule was unlawful because it established water-quality criteria that ignored causation, regulated water bodies that were achieving their designated use, and restricted nutrients that do not cause impairment. The federally directed nutrient rule signed on December 6 would replace the nutrient criteria that were already being used by Florida's Department of Environmental Protection (Fertilizer Week, 2010g).

The U.S. International Trade Commission and the U.S. Department of Commerce International Trade Administration filed Federal Register notices on December 1 regarding the 5-year sunset review of solid urea imports from Russia and Ukraine (U.S. International Trade Commission, 2010). The review was to determine whether terminating the antidumping duty order on solid urea would lead to continuation or recurrence of material injury to the industry in the United States. Urea from Russia and Ukraine has been subject to dumping duties since 1987. The investigation was expected to be completed by yearend 2011.

Under EPA's Greenhouse Gas Reporting Program, owners and operators of facilities that manufacture ammonia were to report emissions from ammonia manufacturing processes and all other source categories located at their facilities beginning in 2010. EPA's rule for the mandatory reporting of greenhouses gases (GHG) from large GHG emissions sources in the United States was published October 30, 2009. Owners or operators were required to collect emission data; calculate GHG emissions; and follow the specified procedures for quality assurance, missing data, recordkeeping, and reporting (U.S. Environmental Protection Agency, 2011).

Production

Industry statistics for anhydrous ammonia and derivative products were developed by the U.S. Census Bureau. A summary of the production of principal inorganic fertilizers by quarter was reported in the series MQ325B. In 2010, production of anhydrous ammonia (82.2% nitrogen) increased about 8% to 8.29 Mt of contained nitrogen compared with the value of 7.70 Mt in 2009 (table 1). Of the total production, 86% was for use as a fertilizer; the remaining 14% was used in other chemical and industrial sectors (table 2).

The United States was a leading producer and consumer of elemental and fixed types of nitrogen. In declining order, urea, ammonium nitrate, ammonium phosphates [diammonium phosphate (DAP) and monoammonium phosphate (MAP)], nitric acid, and ammonium sulfate were the major downstream products derived from domestic and imported ammonia in the United States. Their combined production was 8.60 Mt of contained nitrogen, with urea and ammonium nitrate each accounting for 27% of the total, and ammonium phosphates and nitric acid accounting for 22% and 18%, respectively, of the production (table 3).

Ammonia producers in the United States operated at about 76% of their design capacity in 2010; this percentage included capacities at plants that operated during any part of the year and did not include plants that were idle for all of 2010. Of the total available U.S. ammonia production capacity, more than 59% was concentrated in the States of Louisiana (35%), Oklahoma (19%), and Texas (5%), where there are large reserves of feedstock natural gas. CF Industries Holdings, Inc., Koch Nitrogen Co., LLC, PCS Nitrogen, Inc., and Agrium Inc., in descending order, accounted for 78% of total U.S. ammonia production capacity (table 4).

On April 5, CF Industries concluded its merger with Terra Industries Inc. at a total cost of about $4.7 billion. The combined operations of the two companies will contribute slightly more than one-half of the urea ammonium nitrate solution (UAN) and 38% of the ammonia production capacity in the United States (Fertilizer Week, 2010a).

LSB Industries, Inc.'s, Pryor, OK, facility began limited production in the first quarter of 2010 but did not reach sustained anhydrous ammonia production until the fourth quarter of 2010. The plant was shut down because of a fire in June. The Pryor facility was expected to produce approximately 295,000 metric tons per year (t/yr) of UAN and about 54,000 to 82,000 t/yr of excess anhydrous ammonia available to sell when fully operational (Green Markets, 2010e).

In September, Southeast Idaho Energy LLC received a second permit renewal to construct its proposed $1.5 billion nitrogen facility near American Falls, ID. The nitrogen plant, using advanced clean-coal gasification technology, would produce 453 metric tons per day (t/d) of anhydrous ammonia, 1,630 t/d of granular urea, and 1,450 t/d of UAN. Construction of the plant was anticipated to begin in 2011 (Green Markets, 2010d).

Researchers at the University of Minnesota's Renewable Energy Center at Morris designed a $3.75 million carbon-free system that uses power from a wind turbine to produce anhydrous ammonia. The test plant would produce fertilizer for use on university farmland. Production of anhydrous ammonia using wind power would not be able to compete in the current market; however, if prices for anhydrous ammonia doubled, this process may be economically viable (Green Markets, 2010c).

SynGest, Inc. received a $2.5 million grant from the Iowa Power Fund to help build a planned $130 million corn-based anhydrous ammonia plant near Menlo, IA. The plant was expected to use about 118,000 t/yr of corn cobs to produce 45,000 t/yr of ammonia. SynGest needed to raise another $3.5 million for the construction engineering and design (SynGest, Inc., 2010).

Environment

Hypoxia has become a controversial environmental concern for the fertilizer industry and an issue that spawned significant research efforts to determine its cause. Hypoxia happens where water near the bottom of an affected area in a large body of water, such as the Gulf of Mexico, contains less than 2 parts per million of dissolved oxygen. Hypoxia can cause stress or death in bottom-dwelling organisms that cannot move out of the hypoxic or "dead" zone.

Dead zones in coastal oceans have been reported in more than 400 ecosystems, affecting a total area of more than 245,000 square kilometers worldwide. The number of dead zones has approximately doubled each decade since the 1960s. More recently, dead zones have developed in continental seas, such as the Baltic Sea, the Black Sea, the East China Sea, the Gulf of Mexico, and the Kattegat (Diaz and Rosenberg, 2008).

U.S. Department of Agriculture (USDA) National Resources Conservation Sources (NRCS) launched the Mississippi River Basin Healthy Watersheds Initiative (MRBI) to address agriculture-related nitrogen, phosphorus, and sediment loading in the Mississippi-Atchafalaya River Basin. The request for proposals closed in May for $50 million in financial assistance to projects in priority watersheds in Arkansas, Illinois, Indiana, Iowa, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Ohio, Tennessee, and Wisconsin. The goal of the MRBI was to help farmers and landowners implement conservation practices that would avoid, control, and trap nutrient runoff. NRCS would provide producers with financial and technical assistance and a system of practices that would control soil erosion, improve soil quality, and provide wildlife habitat, while managing runoff and drainage water for improved water quality (Mississippi River Gulf of Mexico Watershed Nutrient Task Force, 2011, p. 22).

The Missouri Department of Natural Resources Soil and Water Conservation coordinated development of the USDA's MRBI in the State of Missouri, which resulted in 12 projects being awarded more than $6 million in 2010. Missouri's MRBI projects involve voluntary implementation of conservation practices to avoid, control, and trap nitrogen and phosphorus runoff, maintain agricultural productivity, adopt system approaches and management strategies to reduce nitrogen and phosphorus runoff, and establish small and large watershed monitoring to document reductions in nitrogen and phosphorus runoff (Mississippi River Gulf of Mexico Watershed Nutrient Task Force, 2011, p. 23).

Consumption

In 2010, apparent consumption of ammonia was 13.8 Mt of contained nitrogen, about 12% higher than that in 2009. Apparent consumption is calculated as production plus imports minus exports, adjusted to reflect any changes in stocks. Consumption of nitrogen fertilizers in the United States for the 2010 crop year (ending June 30, 2010) is listed in table 5. Consumption in fertilizers was estimated to be 10.7 Mt of contained nitrogen, which was slightly higher than that of 2009. Anhydrous ammonia and nitrogen solutions, mostly UAN solutions containing 29.8% to 29.9% nitrogen, were the principal nitrogen fertilizer products, each representing 28% of fertilizer consumption. Urea (45.9% nitrogen) constituted 21% of fertilizer consumption during the 2010 crop year. Ammonium nitrate (33.9% nitrogen) and ammonium sulfate each constituted 2% of 2010 nitrogen fertilizer consumption. The leading nitrogen-consuming States in the 2010 crop year were California, Iowa, Illinois, Kansas, and Nebraska.

Stocks

Stocks of ammonia at yearend 2010 were 165,000 metric tons (t), a slight decrease from comparable stocks at yearend 2009, according to data published by the U.S. Census Bureau (table 6).

Transportation

Ammonia was transported by refrigerated barge, rail car, pipeline, and tank truck. Three companies served 11 States with 5,090 kilometers (km) of pipelines and 4,800 km of river barge transport; rail and truck were used primarily for interstate or local delivery.

NuStar Energy L.P. continued to operate the Gulf Central ammonia pipeline. The 3,200-km ammonia pipeline originated in the Louisiana Delta area, where it had access to three marine terminals and three anhydrous ammonia plants on the Mississippi River. The capacity of this pipeline was about 2 million metric tons per year (Mt/yr) of ammonia, with a storage capacity of more than 1 Mt. In 2010, about 1.4 Mt of ammonia was shipped through the Gulf Central ammonia pipeline (NuStar Energy L.P., 2011, p. 13).

Magellan Midstream Partners, L.P. owned a common carrier ammonia pipeline system. The 1,750-km pipeline system, which transported and distributed ammonia from production facilities in Texas and Oklahoma to various distribution plants in the Midwest, had a delivery capacity of about 820,000 t/yr. In 2010, 419,000 t of ammonia was shipped through Magellan's pipeline compared with 583,000 t in 2009 (Magellan Midstream Partners, L.P., 2011, p. 35). Tampa Pipeline Corp. operated the 135-km Tampa Bay Pipeline system, which moved ammonium phosphate and nitrogen compounds for fertilizer producers in Hillsborough and Polk Counties, FL.

Prices

Midyear and yearend prices for nitrogen materials are listed in table 7. The average gulf coast ammonia price began 2010 at $275 per short ton ($303 per metric ton), and in March reached the high for the year of $420 per short ton ($463 per metric ton), where it remained until yearend, a 29% increase in price from the average high for 2009.

The average granular urea price fluctuated throughout 2010, beginning the year at $316 per short ton ($348 per metric ton). The average price reached a high of $386 per short ton ($425 per metric ton) in mid-November. At yearend, the average urea price was $375 per short ton ($413 per metric ton).

The average ammonium nitrate price, which began 2010 at $273 per short ton ($301 per metric ton), increased throughout the year. The average price rose to $375 per short ton ($413 per metric ton) by early December and then decreased slightly to $368 per short ton ($406 per metric ton) by yearend.

Typically, ammonium sulfate prices do not follow the same trend as other nitrogen products, which correlate to natural gas prices, mainly because a substantial portion of the material is produced as a byproduct of caprolactam production. Caprolactam, an organic compound, is the precursor to Nylon 6, a widely used synthetic polymer. The average price began 2010 at about $198 per short ton ($218 per metric ton) and fluctuated, reaching a low of $170 per short ton ($187 per metric ton) in early July. By yearend, the price reached an average of $280 per short ton ($309 per metric ton).

In 2010, the annual average prices paid for fertilizers increased slightly. Fertilizer prices began to increase because the annual average cost of natural gas, the primary feedstock for nitrogen fertilizers, increased by 13% in 2010 compared with the annual average in 2009 (U.S. Department of Agriculture, Economic Research Service, 2011a).

Foreign Trade

Ammonia exports were 115% higher than those in 2009 (table 8). Canada and Chile were the leading destinations for U.S. exports of ammonia; together accounting for 85% of the total.

Ammonia imports were about 23% higher than those in 2009 and dwarfed the quantity of exports. The average value of ammonia imports increased to $392 per metric ton from $285 per metric ton in 2009 (table 9). Trinidad and Tobago (66%) continued to be the leading import source. Canada (15%) and Ukraine (7%) were the remaining significant import sources.

Tables 10 and 11 list trade data for other nitrogen materials and include information on principal destination or source countries. Exports of nitrogen materials decreased in 2010, with the exception of anhydrous ammonia and MAP. Import quantities of nitrogen materials were higher than imports in 2009 for most nitrogen compounds. The exceptions were calcium nitrate, potassium nitrate and sodium nitrate mixtures, and sodium nitrate.

World Review

Anhydrous ammonia and other nitrogen materials were produced in more than 70 countries. Global ammonia production in 2010, estimated to be 131 Mt, was about 3% higher than that of 2009 (table 12). China, with 31% of total production, was the leading world producer of ammonia. Asia contributed 48% of total world ammonia production, and the Commonwealth of Independent States (CIS), Estonia, and Lithuania produced 13% of the global total. North America represented 10% of the total; Middle East, 8%; Western Europe, 7%; Central America and South America together, 6%; and Africa, Eastern Europe, and Oceania together contributed the remaining 8%.

In 2010, world ammonia exports, estimated to be 14.8 Mt of contained nitrogen, were higher than those in 2009. Canada, Indonesia, Russia, Saudi Arabia, Trinidad and Tobago, and Ukraine accounted for about 66% of the world export total. North America (primarily the United States) imported 39% of global ammonia import trade, followed by Asia (36%) and Western Europe (10%) (International Fertilizer Industry Association, 2011).

Argentina.—Tierra Del Fuego Power & Chemical Co., Ltd. (a joint venture between Jinduicheng Molybdenum Group, Co., Ltd., Shaanxi Coal and Chemical Industry Group, Co., Ltd., and Shaanxi Xinyida Investment Ltd.) contracted with KBR Inc. to develop a greenfield ammonia plant in Tierra Del Fuego, at the southern tip of the country. The ammonia plant was projected to produce 495,000 t/yr and was expected to be completed in 2013 (Nitrogen + Syngas, 2010a).

Australia.—Orica Ltd. planned an ammonia plant expansion and new ammonium nitrate plant at Kooragang Island. The expansion would add about 65,000 t/yr of ammonia and 320,000 t/yr of ammonium nitrate, costing AUD110 million and AUD600 to AUD750 million, respectively. The ammonium nitrate plant was expected to be completed by 2014 or 2015 (Nitrogen + Syngas, 2010c).

Perdaman Chemicals and Fertilisers Pty. Ltd. secured Federal environmental approval to allow construction of a $3.3 billion urea manufacturing facility in Collie, about 200 km south of Perth, Western Australia. The plant would be the first to use gasification technologies to produce 1.6 Mt/yr of ammonia and 2 Mt/yr of urea from subbituminous coal. Construction was expected to begin in 2012 with completion by 2014. Output would be aimed for Asia, North America, and South America (Nitrogen + Syngas, 2010b).

Bangladesh.—Bangladesh's cabinet approved construction of a 578,000-t/yr urea plant at Fenchuganj, 280 km northeast of Dhaka. The China National Complete Plant Import and Export Corp. Ltd. was awarded the contract to construct the plant. No timetable for construction was announced (Nitrogen + Syngas, 2010d).

Brazil.—Petróleo Brasiliero S.A. (Petrobras) planned to develop a 760,000-t/yr ammonia and a 1.2-Mt/yr urea plant at

Tres Lagoas in Mato Grosso do Sul State. Petrobras awarded a contract to KBR to provide licensing, basic and extended engineering, and technical consulting services to develop the ammonia plant (Fertilizer Week, 2010e, f). Petrobras also awarded Stamicarbon B.V. (a subsidiary of Marie Tecnimont S.p.A.) a contract to provide the license, process design, and related services for the urea plant. The new plant would be the second Stamicarbon urea plant in Brazil. Natural gas for the plant would come from Bolivia through the Brazil-Bolivia gas pipeline. The plant was expected to be completed by 2014 (Nitrogen + Syngas, 2010e).

China.—Huaqiang Chemical Group Co. planned to invest $585 million to build five new projects in Dangyang County, Hubei Province, including a 400,000-t/yr ammonia unit and a 600,000-t/yr urea unit. No timetable for construction was announced (Fertilizer Week, 2010d).

Sinochem Group reached an agreement with the provincial government of Ningxia Province to build a nitrogen fertilizer production complex. Sinochem would invest $2.34 billion in the complex, which would include 2.0 Mt/yr of ammonia production capacity and 3.2 Mt/yr of urea production capacity. The complex would be based on coal gasification. No timetable for construction was announced (Nitrogen + Syngas, 2010g).

China XLX Fertiliser Ltd. announced plans to spend $450 million to build a fourth urea plant close to its existing plants at Xinxiang City in Henan Province. The new plant was expected to have a production capacity of 800,000 t/yr of urea and was scheduled for completion in 2013 (Nitrogen + Syngas, 2010f).

Stamicarbon announced that it signed a license agreement with Mongolia Bodashidi Co., Ltd. for a 945,000-t/yr urea plant. The plant would be built in the Industrial Zone of Nalinriver, Wushe, Inner Mongolia. The plant was expected to be completed by 2013 (Nitrogen + Syngas, 2011a).

In December, the Chinese Government released its 2011 tariff rates for many products, including urea, to discourage exports during periods of high domestic demand. The surcharge for urea would be 110% during the high seasons, which were from January through June and November through December (Fertilizer Week, 2010b).

Cuba.—CuVenPeq S.A. established a joint venture with the Cuban Government and Venezuela's Pequiven S.A. to build a 726,000-t/yr granulated urea plant at Calicito, Cienfuegos. Toyo Engineering Corp. was awarded the contract for license and development of the basic design of the urea facility, with Haldor Topsoe A/S technology slated for the associated 610,000-t/yr ammonia plant. Production was scheduled to begin in 2014 (Nitrogen + Syngas, 2010h).

Egypt.—El-Delta Co. for Fertilizers and Chemical Industries issued an invitation to bid for the engineering, procurement, and construction contract for its new 1,200-t/d ammonia plant at its Talkha fertilizer complex in Dakahliy. The plant was expected to take 36 months to complete at a cost of $300 million (Fertilizer Week, 2010c).

Gabon.—Olam International Ltd. formed a joint venture with the Government of Gabon to build an ammonia-urea complex with a total investment of $1.3 billion. The plant capacity was expected to be 736,000 t/yr of ammonia and 1.27 million t/yr of urea, with completion expected by 2015 (Nitrogen + Syngas, 2011b).

India.—Zuari Industries Ltd. signed a natural gas agreement with the Gas Association of India Ltd. for its ammonia-urea unit in Gao. The 413,000-t/yr plant was to be converted from naptha feedstock to natural gas beginning in January 2013 (Nitrogen + Syngas, 2010j).

India's National Fertilizers Ltd. awarded $465 million to Larsen & Tourbro Ltd. to convert two ammonia plants from heavy fuel feedstock to run on natural gas. The plants, at Panipat in Haryana State and at Bathinda in Punjab State, each with an ammonia production capacity of 300,000 t/yr, were expected to be operational by January 2013 (Nitrogen + Syngas, 2010i).

The Bengal government allotted land to Matrix Fertilisers & Chemicals Ltd. to establish a natural gas-based urea plant. The first phase would consist of a 2,200-t/d ammonia plant and a 3,850-t/d (1.3 Mt/yr) urea plant, which was expected to be completed by 2012. The second phase would increase the urea capacity to 3.0 Mt/yr. KBR was awarded the contract to provide licensing and engineering services for the plant, which would use coal-bed methane as feedstock for ammonia synthesis. The Matrix plant would market its urea in east India (Green Markets, 2010a; Telegraph, The, 2010).

Russia.—JSC Salavatnefteorgsynthes was converting its urea plant at Slavat in western Russia to produce granular urea. The 460,000-t/yr granulation unit was expected to handle output from two urea trains with production capacities of 260,000 t/yr and 370,000 t/yr. Toyo Engineering would provide the granulation technology license and basic design work. The cost of the conversion was estimated to be $38 million, and conversion was scheduled to begin in 2011 (Nitrogen + Syngas, 2010k).

JSC Ammonia awarded China National Chemical Engineering Corp. and Japan's Mitsubishi Heavy Industries Inc., Ltd. and Sojitz Corp. a $1 billion contract to build a large-scale urea, ammonia, and methanol plant in the Russian Republic of Tatarstan at Mendeleevsk about 1,000 km east of Moscow. Production capacities were expected to be about 676,500 t/yr of ammonia or 460,000 t/yr of ammonia and 220,000 t/yr of methanol in the case of coproduction. Technology would be supplied by Haldor Topsoe, Saipem S.p.A., and Uhde GmbH Fertilizer Technology. The plant was expected to begin production in 2015 (Nitrogen + Syngas, 2011c).

Turkmenistan.—Kawasaki Plant Systems Ltd. entered into an agreement with M.W. Kellogg Ltd., a unit of KBR, to provide licensing and basic engineering design for the Mary Project's 400,000-t/yr ammonia and 635,000-t/yr urea plants. The plants were scheduled to be completed by 2013 (Green Markets, 2010b; Nitrogen + Syngas, 2010l).

Uzbekistan.—JSC NIIK was awarded a contract to modernize and reequip KSC Maxam-Chirchiq's urea plant at Chirchiq in Uzbekistan. The project was expected to expand the urea production capacity to 270,000 t/yr. Completion of the project was scheduled for December 2011 (Nitrogen + Syngas, 2010m).

Vietnam.—Ha Bac Nitrogen Fertilizers and Chemicals Co. planned to upgrade and expand its HA Bac Nitrogen Fertilizers' plant. The project would raise the production capacity of the coal gasification-based plant from 180,000 t/yr to 500,000 t/yr of urea. The urea would be used for the Vietnamese domestic market. The expansion was expected to take 42 months at a cost of $373 million (Nitrogen + Syngas, 2010n).

Zimbabwe.—TA Holdings Ltd. planned to spend $40 million during a 4-year period to refurbish Sable Chemicals Industries Ltd.'s ammonia plant that was closed in 2009. Sable originally had planned to import ammonia from South Africa for its nitrogen fertilizer plant in Kwekwe but this option was deemed unreliable owing to supply inconsistencies related to logistic problems and the amount of ammonia required (Herald, The, 2010).

Outlook

According to the USDA, U.S. corn growers intended to plant 37.3 million hectares (Mha) of corn for all purposes in the 2011 crop year, an increase of 5% from that in 2010 and an increase of 7% from that in 2009 (U.S. Department of Agriculture, National Agricultural Statistical Service, 2011, p. 1). Expectations of corn acreage utilization increased in many States because of higher selling prices and expectations of better net returns from corn compared to other commodities.

According to long-term projections from the USDA, projected plantings for the eight major field crops (barley, corn, oats, rice, sorghum, soybeans, upland cotton, and wheat) in the United States were expected to increase to 101 Mha during the projection period (2011–20) from about 99 Mha in 2010. Increased cropland availability (resulting from the reduction in the allowable acreage enrolled in the Conservation Reserve Program), demand, and sustained high commodity prices were expected to keep projected U.S. cropland use high. Corn, soybeans, and wheat were expected to account for about 89% of acreage utilization for the eight major field crops during the projection period. During the 10-year period, the crop mix was expected to keep corn acreage high. Soybean planting likely would rise during the projection period as growth in domestic and foreign demand keeps prices high and returns favorable for producers. Wheat plantings probably would decline as a result of weak demand and significant quantities of stocks. Continued high levels of domestic corn-based ethanol and gains in exports were projected to keep corn demand high. Most U.S. ethanol production used corn as a feedstock, with nearly one-third of total corn use expected to go to ethanol production through 2020. Projected gains were largely in line with moderate expected increases in overall gasoline usage in the United States, which represent more than 10% of the annual gasoline consumption. Relatively high prices for crude oil would be favorable for ethanol production, which, when combined with Government programs, would provide economic incentives for ethanol producers.

Feed and residual use of corn is projected to bottom out in the initial years of the period owing to reduced meat production and increased feeding of distillers grains (a coproduct of dry mill ethanol production). Feed use is expected to rise through the rest of the period, as meat production increases and growth in the availability of distillers grains slows with the decrease in corn-based ethanol expansion. Increases in food and industrial uses of corn (other than for ethanol production) are projected to rise during the next decade. Consumer dietary concerns and other changes in tastes and preferences limit increases in the combined use of corn for dextrose, glucose, and high-fructose corn syrup to about one-half the rate of population gain. Other food uses of corn also are projected to rise more slowly than the increase in population. U.S. corn exports rise in response to stronger global demand for feed grains to support growth in meat production; the U.S. share of global corn trade remains above 50%. Larger corn plantings increase the demand for nitrogen fertilizers (U.S. Department of Agriculture, Economic Research Service, 2011b, p. 60–61).

In 2010, natural gas prices increased 13% after the low prices of 2009, which was a 7-year low resulting from a weakened economy, a reduced heating demand, as well as higher than usual production and storage levels. Natural gas prices in the United States typically are higher than those in the rest of the world, but lower natural gas prices make U.S. ammonia production more competitive with offshore imports. Depending on its price, natural gas can account for approximately 75% to 90% of the U.S. cash cost of producing ammonia, and this means that the ammonia capacity at older, higher cost U.S. plants is still at risk for closure. The Middle East, North Africa, Russia, Trinidad and Tobago, and Venezuela have ample supplies of lower-cost natural gas, which is a cost advantage to producing and exporting ammonia. U.S. ammonia production was comparatively high, primarily owing to shale gas developments that have increased domestic supply (Potash Corp. of Saskatchewan, 2011, p. 35). The U.S. Department of Energy projected that the Henry Hub natural gas spot price in the United States would average $4.26 million British thermal units (Btus) in 2011, an $0.11 decrease from the 2010 average, and $4.54 per million Btus in 2012 (U.S. Department of Energy, Energy Information Administration, 2011, p. 6).

In the winter of 2001, natural gas prices began to spike and continued to increase through the third quarter of 2008, and as a result, U.S. ammonia production capacity declined by 4.1 Mt/yr, or 24% of the 2001 capacity. In 2010, natural gas prices increased by about 10% from those of 2009, which were still relatively low owing to weak industrial demand and competition from shale gas. Still relatively low compared with the 2008 prices, natural gas prices in 2010 made domestic nitrogen production more competitive with imports from major nitrogen-exporting regions. The future of U.S. ammonia production depends on the variability in natural gas prices. The interest that U.S. firms have in constructing new plants outside the United States, particularly in Trinidad and Tobago where natural gas prices are lower, indicates that in the future, much of the U.S. supply of ammonia is expected to be met by foreign production.

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TABLE 1
SALIENT AMMONIA STATISTICS[1, 2]

(Thousand metric tons of contained nitrogen unless otherwise specified)

		2006	2007	2008	2009	2010
United States:						
Production		8,190	8,540	7,870	7,700	8,290 [p]
Exports		193	145	192	16	35
Imports for consumption		5,920	6,530	6,020	4,530	5,540
Consumption, apparent[3]		14,000	15,000	13,500 [r]	12,300	13,800 [p]
Stocks, December 31, producers		201	157	302	167	165
Average annual price, free on board gulf coast[4]	dollars per short ton	302	307	590	251	396
Net import reliance as a percentage of apparent consumption[5]		41	43	41	38	40 [p]
Natural gas price, wellhead, average price[6]	dollars per thousand cubic feet	6.39	6.25	7.97 [r]	3.67 [r]	4.16 [e]
World:						
Production[e]		125,000 [r]	131,000	130,000	127,000 [r]	131,000
Trade[7]		15,900	15,800	15,500 [r]	14,400 [r]	14,800 [e]

[e] Estimated. [p] Preliminary. [r] Revised.

[1] Data are rounded to no more than three significant digits.

[2] Synthetic anhydrous ammonia, excluding coke oven byproduct; data are for calendar year and are from the U.S. Census Bureau unless otherwise noted.

[3] Calculated from production plus imports minus exports and industry stock changes.

[4] Source: Green Markets.

[5] Defined as imports minus exports; adjusted for industry stock changes.

[6] Source: Monthly Energy Review, U.S. Department of Energy.

[7] Source: International Fertilizer Industry Association Statistics, World Anhydrous Ammonia Trade.

TABLE 2

ANHYDROUS AMMONIA SUPPLY AND DEMAND IN THE UNITED STATES[1]

(Thousand metric tons of contained nitrogen)

	2008	2009	2010^{p}
Production:			
Fertilizer:			
January–June	3,520	3,040	3,550
July–December	3,210	3,430	3,580
Total	6,730	6,470	7,130
Nonfertilizer:			
January–June	542	603	577
July–December	594	632	585
Total	1,140	1,240	1,160
Grand total	7,870	7,700	8,290
Exports:			
January–June	53	9	28
July–December	139	7	7
Total	192	16	35
Imports for consumption:			
January–June	3,290	2,180	2,630
July–December	2,720	2,340	2,910
Total	6,020	4,530	5,540
Stocks, end of period:			
January–June	193	201	149
July–December	302	167	165
Apparent consumption:[2]			
January–June	7,260 ^{r}	5,920 ^{r}	6,750
July–December	6,280 ^{r}	6,430 ^{r}	7,050
Total	13,500 ^{r}	12,300	13,800

^{p}Preliminary. ^{r}Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Calculated from production plus imports minus exports and industry stock changes.

Source: U.S. Census Bureau.

TABLE 3

MAJOR DOWNSTREAM NITROGEN COMPOUNDS PRODUCED IN THE UNITED STATES[1, 2]

(Thousand metric tons)

	2009						2010^{p}					
	January–June		July–December		Total		January–June		July–December		Total	
	Gross weight	Nitrogen content	Gross weight	Nitrogen content	Gross weight	Nitrogen content	Gross weight	Nitrogen content	Gross weight	Nitrogen content	Gross weight	Nitrogen content
Urea	2,490	1,140	2,600	1,190	5,080	2,330	2,680	1,230	2,450	1,120	5,120	2,350
Ammonium nitrate	2,920	991	3,380	1,140	6,300	2,140	3,410	1,160	3,380	1,150	6,790	2,300
Ammonium phosphates[3]	5,090	815	6,310	1,010	11,400	1,820	5,790	904	6,340	987	12,100	1,890
Nitric acid	2,560	562	3,370	741	5,930	1,300	3,490	767	3,450	758	6,930	1,530
Ammonium sulfate[4]	1,160	246	1,110	235	2,270	481	1,300	274	1,190	253	2,490	527

^{p}Preliminary.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Ranked in relative order of importance by nitrogen content.

[3] Diammonium phosphate and monoammonium phosphate.

[4] Excludes coke plant ammonium sulfate.

Source: U.S. Census Bureau, Current Industrial Reports MQ325B.

TABLE 4
DOMESTIC PRODUCERS OF ANHYDROUS AMMONIA IN 2010[1]

(Thousand metric tons per year of ammonia)

Company	Location	Capacity[2]
Agrium Inc.	Borger, TX	490
Do.	Kennewick, WA[3]	180
CF Industries Holdings, Inc.	Donaldsonville, LA	2,490
Do.	Port Neal, IA	336
Do.	Verdigris, OK	953
Do.	Woodward, OK	399
Do.	Yazoo City, MS	454
Coffeyville Resources Nitrogen Fertilizers, LLC	Coffeyville, KS	375
Dakota Gasification Co.	Beulah, ND	363
Dyno Nobel Inc.	Cheyenne, WY	174
Do.	St. Helens, OR	101
Eastman Chemical Co.	Beaumont, TX[3]	231
Green Valley Chemical Corp.	Creston, IA	32
Honeywell International Inc.	Hopewell, VA	530
Koch Nitrogen Co.	Beatrice, NE	265
Do.	Dodge City, KS	280
Do.	Enid, OK	930
Do.	Fort Dodge, IA	350
Do.	Sterlington, LA[3]	1,110
LSB Industries, Inc.	Cherokee, AL	159
Do.	Pryor, OK[3]	210
Mosaic Co., The	Faustina (Donaldsonville), LA	508
PCS Nitrogen, Inc.	Augusta, GA	688
Do.	Geismar, LA[3]	483
Do.	Lima, OH	542
Do.	Memphis, TN[3]	372
Rentech Energy Midwest Corp.	East Dubuque, IL	278
Total		13,300

Do. Ditto.

[1] Data are rounded to no more than three significant digits; may not add to total shown.

[2] Engineering design capacity adjusted for 340 days per year of effective production capability.

[3] Idle.

TABLE 5

U.S. NITROGEN FERTILIZER CONSUMPTION, BY PRODUCT TYPE[1, 2]

(Thousand metric tons of nitrogen)

Fertilizer material[3]	2009[r]	2010[e]
Single-nutrient:		
Anhydrous ammonia	2,980	3,040
Nitrogen solutions[4]	2,910	2,970
Urea	2,180	2,220
Ammonium nitrate	233	238
Ammonium sulfate	229	234
Aqua ammonia	83	85
Other[5]	375	383
Total	8,990	9,170
Multiple-nutrient[6]	1,530	1,560
Grand total	10,500	10,700

[e] Estimated. [r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Fertilizer years ending June 30.

[3] Ranked in relative order of importance by product type.

[4] Principally urea-ammonium nitrate solutions, 29.9% nitrogen.

[5] Includes other single-nutrient nitrogen materials, all natural organics, and statistical discrepencies.

[6] Various combinations of nitrogen (N), phosphate (P), and potassium (K): N-P-K, N-P, and N-K.

Source: Slater, J.V., and Kirby, B.J., 2011, Commercial Fertilizers 2009: Columbia, MO, Association of American Plant Food Control Officials Inc. Fertilizer/Ag Lime Control Service, University of Missouri, 42 p.

TABLE 6
U.S. PRODUCER STOCKS OF FIXED NITROGEN COMPOUNDS AT END OF PERIOD

(Thousand metric tons of contained nitrogen)

Material[1]	2009	2010[p]
Ammonia:		
January–June	201	149
July–December	167	165
Nitrogen solutions:[2]		
January–June	153	93
July–December	95	111
Urea:		
January–June	W	37
July–December	W	W
Ammonium phosphates:[3]		
January–June	17 [4]	53
July–December	44	W
Ammonium nitrate:		
January–June	48	24
July–December	32	36
Ammonium sulfate:		
January–June	20	44
July–December	26	16
Yearend total[5]	364	328

[p] Preliminary. W Withheld to avoid disclosing company proprietary data.

[1] Ranked in relative order of importance.

[2] Urea-ammonium nitrate and ammoniacal solutions.

[3] Diammonium and monoammonium phosphates.

[4] Diammonium phosphates data withheld.

[5] Calendar year ending December 31.

Source: U.S. Census Bureau, Current Industrial Reports MQ325B.

TABLE 7
PRICE QUOTATIONS FOR MAJOR NITROGEN COMPOUNDS AT END OF PERIOD

(Dollars per short ton)

Compound	2009		2010	
	June	December	June	December
Ammonium nitrate, free on board (f.o.b.) corn belt[1]	265–270	265–270	305–325	350–383
Ammonium sulfate, f.o.b. corn belt[1]	225–245	185–210	230–250	270–290
Anhydrous ammonia:				
F.o.b. corn belt[1]	300–345	340–390	380–455	640–685
F.o.b. gulf coast[2]	255	275	420	420
Diammonium phosphate, f.o.b. central Florida	250–255	320	395–400	540–550
Urea:				
F.o.b. corn belt,[1] prilled and granular	270–285	350–360	280–310	415–440
F.o.b. gulf coast, granular[2]	240–245	307–315	240–253	370–380

[1] Illinois, Indiana, Iowa, Missouri, Nebraska, and Ohio.

[2] Barge, New Orleans, LA.

Source: Green Markets.

TABLE 8
U.S. EXPORTS OF ANHYDROUS AMMONIA, BY COUNTRY[1]

(Thousand metric tons of ammonia and thousand dollars)

Country	2009		2010	
	Gross weight	Value[2]	Gross weight	Value[2]
Belgium	1	526	2	565
Canada	15	7,190	15	7,510
Chile	--	--	21	7,910
Haiti	1	207	1	274
Israel	1	288	1	404
Other	2	861	3	1,450
Total	20	9,070	43	18,100

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.
[2] Cost, insurance, and freight value.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS OF ANHYDROUS AMMONIA, BY COUNTRY[1]

(Thousand metric tons of ammonia and thousand dollars)

Country	2009		2010	
	Gross weight	Value[2]	Gross weight	Value[2]
Australia	80	22,200	--	--
Canada	822	357,000	1,010	451,000
Egypt	96	29,400	90	40,100
Latvia	--	--	76	33,600
Russia	438	133,000	281	105,000
Trinidad and Tobago	3,720	936,000	4,450	1,670,000
Ukraine	67	20,400	479	196,000
Venezuela	158	36,900	88	32,300
Other	126	36,000	265	111,000
Total	5,510	1,570,000	6,740	2,640,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.
[2] Cost, insurance, and freight value.

Source: U.S. Census Bureau.

TABLE 10
U.S. EXPORTS OF MAJOR NITROGEN COMPOUNDS[1]

(Thousand metric tons)

	2009		2010		
Compound	Gross weight	Nitrogen content	Gross weight	Nitrogen content	Principal destinations in 2010
Ammonium nitrate[2]	364	123	355	120	Canada, 49%; Mexico, 30%; France, 10%; Australia, 10%.
Ammonium sulfate[2]	963	204	938	199	Brazil, 44%; Dominican Republic, 10%; Peru 13%.
Anhydrous ammonia	20	16	43	35	Canada, 47%; Chile, 35%.
Diammonium phosphate	5,530	996	4,090	736	India, 62%; Mexico, 5%.
Monoammonium phosphate	2,110	232	2,330	256	Canada, 28%; Brazil, 25%; Australia, 14%; Argentina, 11%.
Urea	289	133	152	70	Canada, 45%; Mexico, 19%; Chile, 16%; Columbia, 12%.
Total	9,280	1,700	7,910	1,420	

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes industrial chemical products.

Source: U.S. Census Bureau.

TABLE 11
U.S. IMPORTS OF MAJOR NITROGEN COMPOUNDS[1]

(Thousand metric tons and thousand dollars)

	2009			2010			
Compound	Gross weight	Nitrogen content	Value[2]	Gross weight	Nitrogen content	Value[2]	Principal sources in 2010
Ammonium nitrate[3]	451	153	98,900	576	195	151,000	Canada, 61%; Georgia, 14%; Netherlands, 12%.
Ammonium nitrate and limestone mixtures	51	14	11,100	103	28	26,200	Ukraine, 40%; Austria, 27%; Netherlands, 24%.
Ammonium sulfate[3]	324	69	67,300	357	76	66,100	Canada, 99%.
Anhydrous ammonia[4]	5,510	4,530	1,570,000	6,740	5,540	2,640,000	Trinidad and Tobago, 66%; Canada, 15%.
Calcium nitrate	123	21	14,600	34	6	4,530	Norway, 82%.
Diammonium phosphate	22	4	9,710	190	34	101,000	Morocco, 41%; Russia, 37%; Lithuania, 12%.
Monoammonium phosphate	57	6	34,500	263	29	146,000	Russia, 38%; Canada, 30%; Morocco, 13%; China, 10%.
Nitrogen solutions	1,170	349	257,000	2,210	660	504,000	Russia, 20%; Trinidad and Tobago, 18%; Canada, 10%.
Potassium nitrate	74	10	48,500	77	11	45,700	Chile, 84%.
Potassium nitrate and sodium nitrate mixtures	1	(5)	(5)	(5)	(5)	250	Canada, 94%.
Sodium nitrate	84	14	20,600	73	12	22,800	Chile, 87%; Germany, 10%.
Urea	4,730	2,170	1,440,000	6,630	3,040	2,220,000	Canada, 26%; China, 11%.
Total	12,600	7,330	3,570,000	17,300	9,640	5,930,000	

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight value.

[3] Includes industrial chemical products.

[4] Includes industrial ammonia.

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 12

AMMONIA: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons, contained nitrogen)

Country	2006	2007	2008	2009	2010
Afghanistan	20	20	20	20	20
Albania	10	10	10	10	10
Algeria	470	524	500	614	822
Argentina	727 [3]	726	726	570 r	600
Australia	1,200	1,200	1,200	1,200	1,200
Austria	400 r	400 r	400 r	300 r	350
Bahrain	370 [3]	344 [3]	350	350	350
Bangladesh[4]	1,250	1,300	1,300	1,300	1,300
Belarus	815	830	805 [3]	750	800
Belgium	850	850	850	850	850
Bosnia and Herzegovina	1	1	1	1	1
Brazil	950	950	950	950	950
Bulgaria	309	310	310	310	310
Burma	30	30	30	30	30
Canada	4,100	4,498 [3]	4,781 [3]	4,000	4,000
China[3]	40,660	42,480	41,140	42,290	40,870
Croatia	319 [3]	320	320	320	300
Cuba	42 [3]	47 [3]	42	27 r	27
Czech Republic	250	225	200	200	200
Denmark	2	2	2	2	2
Egypt	1,800	1,750	1,750	2,000	3,000
Estonia	170	170	170	170	170
Finland	62	62	62	62	60
France	616 [3]	800	800	800	800
Georgia	140	150	150	150	150
Germany[3]	2,718	2,746	2,819	2,363	2,677
Greece	130	130	130	125	120
Hungary	275	300	300	300	300
India[5]	10,900	11,000	11,100	11,200	11,500
Indonesia	4,300	4,400	4,500	4,600	4,800
Iran	1,020	2,000	2,000	2,000	2,500
Iraq	10	10	10	10	550
Italy	480 [3]	460	460	460	460
Japan[3]	1,091	1,114	1,244 r	1,021 r	1,000
Korea, North	100	100	100	100	100
Korea, Republic of	90	--	--	--	--
Kuwait	495	485	485	470 r	480
Libya[3]	518	523	417	488 r	580
Lithuania	453 [3]	936 [3]	950	950	950
Malaysia	950	960	950	950	950
Mexico[3]	487	714 r	826 r	895 r	826
Netherlands	1,800	1,800	1,800	1,800	1,800
New Zealand	120	125	125	125	125
Norway	350	350	350	350	350
Oman	1,000	1,000	1,000	1,000	1,000
Pakistan	2,200	2,250	2,300	2,300	2,400
Peru	5	5	5	5	5
Poland[3]	2,007	1,995	1,995	1,697 r	1,800
Portugal	244	244	244	244	244
Qatar	1,500 r	1,500 r	1,600 r	1,700 r	1,700
Romania	1,300	1,300	1,300	1,100 r	1,100

See footnotes at end of table.

TABLE 12—Continued

AMMONIA: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons, contained nitrogen)

Country	2006	2007	2008	2009	2010
Russia	10,500 [3]	10,500	10,425 [3]	10,441 [3]	10,400
Saudi Arabia	2,000	2,600	2,600	2,600	2,600
Serbia	80	85	47 [r]	53 [r]	55
Slovakia	241 [3]	260	260	260	260
South Africa	480	480	480	430	450
Spain	400	400	400	400	400
Switzerland	32	32	32	32	32
Syria	120	120	120	210	260
Taiwan	12	12	12	12	12
Tajikistan	35	25	25	20	20
Trinidad and Tobago	5,111 [3]	5,129 [3]	5,130	4,946 [r, 3]	5,000
Turkey	92 [3]	-- [3]	50	100	100
Turkmenistan	250	270	270	270	270
Ukraine	4,200	4,200	4,000 [r]	2,500 [r]	3,400
United Arab Emirates	380	380	380	380	400
United Kingdom	750	1,050	1,100	1,100	1,100
United States[3, 6]	8,190	8,540	7,870	7,700	8,290 [p]
Uzbekistan	940	1,000	1,000	1,000	1,000
Venezuela	1,160	1,160	1,160	1,160	1,160
Vietnam	230	300	300	300	300
Zimbabwe	10	35	25	25 [r]	25
Total	125,000 [r]	131,000	130,000	127,000 [r]	131,000

[p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 24, 2011.

[3] Reported figure.

[4] May include nitrogen content of urea.

[5] Data are for years beginning April 1 of that stated.

[6] Synthetic anhydrous ammonia; excludes coke oven byproduct ammonia.

PEAT

By Lori E. Apodaca

Domestic survey data and tables were prepared by Robert H. Bradley, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, peat produced in the conterminous United States was 628,000 metric tons (t); output from Alaska was estimated to be 59,800 cubic meters (Szumigala and others, 2011, p. 44). World peat production for 2010 was estimated to be 23.4 million metric tons (Mt). The leading peat producing countries were Finland, Ireland, Belarus, Sweden, Russia, Canada, and Latvia, in decreasing order of tonnage (table 9).

The United States was a significant producer and consumer of peat for horticultural and industrial purposes. The types of peat are classified according to the degree of decomposed component plant material, with sphagnum moss being the least decomposed followed by hypnum moss, reed-sedge, and humus.

Reed-sedge accounted for 83% of domestic peat production, followed by sphagnum moss with 11%; hypnum moss with 4%; and humus with 2% (table 4). Florida, with 470,000 t, accounted for 75% of U.S. peat production (table 3).

Peat is a natural organic material of botanical origin and commercial significance. Peatlands are situated in wetland areas, primarily in the temperate and cold belt of the Northern Hemisphere, where large peat deposits developed from the gradual decomposition of plant matter under anaerobic conditions. The United States contains approximately 15% of the world's peatlands by area (Lappalainen, 1996, p. 55). There are more than 400 million hectares (Mha) of peatlands on Earth, of which 80% remains undisturbed. Of the 80 Mha that has been used by humans, 50% has been used for agriculture; 30%, for forestry; 10%, for miscellaneous uses; and 10%, for peat extraction. Peat continues to accumulate on 55% of global peatlands; however, the volume of global peat resources has been decreasing at a rate of 0.05% per year owing to human activity (Joosten and Clarke, 2002, p. 32–33).

Production

Domestic production data for peat were developed by the U.S. Geological Survey from a voluntary canvass of operations in the conterminous United States. Of the 42 operations to which a survey request was sent, 28 responded. From the respondents, there were 26 active operations and 2 idle operations in 2010. Data for nonrespondents were estimated based on responses to the 2009 survey or other sources. Most peat operations are relatively small and sell their products regionally. Peat production in the conterminous United States in 2010 was 628,000 t, a 3% increase from that of 2009 (table 1). In 2010, 79% of domestic production came from just six operations (table 2). A slight increase in peat production was reported in the Eastern region, and an increase of 9% was reported for the Great Lakes region (table 3). Output from Alaska was estimated to be 59,800 cubic meters in 2010, according to the Alaska Department of Natural Resources, which conducted its own survey of mineral production in the State (Szumigala and others, 2011, p. 44). Peat production in Alaska was reported by volume only.

Consumption

Peat is widely used as a plant-growth medium in a variety of agricultural and horticultural applications where its fibrous structure and porosity enable a unique combination of optimum water-retention and drainage characteristics. Commercial applications include lawn and garden soil amendments, potting soils, and turf maintenance on golf courses. In industry, peat is used primarily as a filtration medium to remove toxic materials from process waste streams, pathogens from sewage effluents, and deleterious materials suspended in municipal storm-drain water. In its dehydrated form, peat is a highly effective absorbent for fuel and oil spills on land and water.

Sales of domestic peat decreased by 6% to 605,000 t in 2010 from 644,000 t in 2009. Packaged products composed 8% of total domestic sales tonnage and commanded premium prices for all grades of peat. Apparent consumption was estimated to be 8% higher than that of 2009. Potting soil and general soil improvement mixes were the two leading usage categories, accounting for 95% of domestic sales tonnage and 91% of the volume (table 5). Other significant uses, by quantity of sales, included golf course applications, earthworm culture, seed inoculants, and nursery applications. The United States imported 59% of its total consumption requirements, primarily from Canada, where deposits of high-quality sphagnum moss are extensive. Canadian peat was sold in bulk for blending in custom soil mixes and was packaged for horticultural use; however, a detailed distribution of Canadian imports was not available. Many of the soil blending facilities in the Southern and Western United States are owned by subsidiaries of Canadian peat producers and import much of their peat requirements.

Stocks

U.S. yearend stocks of peat decreased by 33% to 100,000 t in 2010 from 149,000 t in 2009 (table 1). Reed-sedge peat accounted for 91% of total stocks, followed by humus, sphagnum moss, and hypnum moss (table 4).

Prices

The total reported free on board (f.o.b.) value for domestic peat sold in the United States was about $15 million, according to the annual survey of domestic peat producers. The average unit value increased by 5% to $24.39 per metric ton compared with $23.24 per ton in 2009 (table 1). On an average unit-value basis, sphagnum moss was valued at $45.95 per ton, f.o.b. plant; hypnum moss, $31.32 per ton; humus, $30.81 per ton; and reed-sedge, $21.48 per ton (table 7).

Foreign Trade

U.S. companies exported 69,000 t of peat (table 1). Imports of peat increased by about 5% to 947,000 t from 906,000 t in 2009 (tables 1 and 8). The total customs import value was $225 million or $237.11 per ton. Imports of peat (sphagnum moss) from Canada increased to 921,000 t, which represented 97% of total U.S. imports and 73% of total Canadian production.

World Review

Finland, Ireland, Belarus, Sweden, Russia, Canada, and Latvia were the leading peat-producing countries, in decreasing order of tonnage (table 9). World peat production for 2010 was estimated to be 23.4 Mt, slightly higher than that of 2009. Other significant producing countries included Estonia, Poland, Ukraine, and the United States. Peat is an important source of energy in Finland, Ireland, and Sweden and to a lesser extent in Eastern Europe.

Canada.—Production of peat (sphagnum moss) was estimated to have increased to 1.26 Mt in 2010 from 1.13 Mt in 2009. New Brunswick, Quebec, Manitoba, and Alberta were the major producing provinces, in decreasing order of tonnage, accounting for about 95% of production. British Columbia, Newfoundland, Nova Scotia, Ontario, Prince Edward Island, and Saskatchewan also reported peat production (Natural Resources Canada, 2011). Favorable climatic conditions in the summer of 2010 allowed increased peat production in Alberta, New Brunswick, and Quebec.

In 2010, Peat Resources Ltd. and BioEnergy Ltd. signed a letter of intent to collaborate on research and development to improve biomass processing technology. Peat Resources has peatland properties in Newfoundland and Ontario and has established a small-scale peat processing facility in Stephenville, Newfoundland (Peat Resources Ltd., 2010).

Indonesia.—Indonesia's president announced a 2-year moratorium on new concessions to convert virgin forests and peatlands into palm oil plantations, part of an internationally backed strategy to reduce greenhouse gas emissions from deforestation. Indonesia is one of the world's largest emitters of greenhouse gases because of its clearing and burning of the forests and peatlands for logging and conversion into palm oil plantations (CNN, 2010).

United Kingdom.—In December, the Department for Environment, Food and Rural Affairs published a consultation on proposals to phase out the horticultural use of peat by amateur gardeners in England by 2020, which was estimated to account for 2 million cubic meters of the United Kingdom's annual peat consumption. Also included were the phase out of peat in the Government and wider public sector by 2015 and the phase out of peat by professional growers of fruit, plants, and vegetables by 2030. By 2030, all markets were to use more sustainable peat-free alternatives (Department for Environment Food and Rural Affairs, 2010). The Department's goal was to preserve peatlands, which may be important for biodiversity, carbon storage, and flood management.

Outlook

The domestic short-term peat situation will likely include steadily increasing Canadian imports and fluctuating domestic peat production. The number of domestic producers likely will continue to decline and remain dominated by large companies. Other factors, such as competition from organic soil amendments like coir (coconut fiber) and composted yard waste, Federal and State wetlands regulations, and restrictions on permitting new production sites likely will reduce or slow the growth of the domestic peat industry. Also, peatlands have been identified as carbon sinks, storing more carbon dioxide per unit hectare than any other ecosystem. Preservation of peatlands may become a high priority in the efforts to reduce greenhouse gas emissions.

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TABLE 1
SALIENT PEAT STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2006	2007	2008	2009	2010
United States:[2]						
Number of active producers		39	38	37	38	38
Production		551	635	615	609	628
Sales by producers:						
Quantity:						
Bulk		525	590	546	559	554
Packaged		209	104	102	85	51
Total		734	694	647 r	644	605
Value		20,100	17,700	17,100	15,000	14,800
Average value	dollars per metric ton	27.34	25.59	26.42	23.24	24.39
Average value, bulk	do.	23.00	24.69	24.73	22.06	24.28
Average value, packaged or baled	do.	38.28	30.64	36.24	31.01	26.48
Exports		41	56	57 e	77	69
Imports for consumption		924	977	936	906	947
Consumption, apparent[3]		1,500	1,590	1,440	1,440	1,560
Stocks, December 31, producers'		128	98	152	149	100
World, production		27,600 r	28,100 r	25,100 r	22,900 r	23,400 e

e Estimated. r Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits, except average values per metric ton.

[2] Excludes Alaska.

[3] Apparent consumption equals U.S. production plus imports minus exports plus adjustments for industry stock changes.

TABLE 2
RELATIVE SIZE OF PEAT OPERATIONS IN THE UNITED STATES

Size (metric tons per year)	Active operations 2009	Active operations 2010	Production (thousand metric tons) 2009	Production (thousand metric tons) 2010
23,000 and more	5	6	453	495
9,000 to 22,999	7	6	97	85
5,000 to 8,999	5	4	33	25
1,000 to 4,999	11	7	22	17
Less than 1,000	10	15	4	7
Total	38	38	609	628

TABLE 3
U.S. PEAT PRODUCTION AND SALES BY PRODUCERS IN 2010, BY STATE[1]

Region and State	Active operations	Production (thousand metric tons)	Sales: Quantity (thousand metric tons)	Sales: Value[2] (thousands)	Sales: Percentage packaged
East:					
Florida	7	470	480	$9,710	3
Pennsylvania	4	2	2	58	39
Other[3]	7	45	42	1,830	1
Total or average	18	517	524	11,600	3
Great Lakes:					
Minnesota	9	74	41	2,500	29
Other[4]	8	34	36	494	64
Total or average	17	108	77	2,990	46
West[5]	3	4	5	163	36
Grand total or average	38	628	605	14,800	9

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Values for free on board producing plant.

[3] Includes Maine, New Jersey, and New York.

[4] Includes Illinois, Indiana, Michigan, and Ohio.

[5] Includes Iowa, Washington, and Wisconsin.

TABLE 4
U.S. PEAT PRODUCTION AND PRODUCERS' YEAREND STOCKS IN 2010, BY TYPE

Type	Active operations[1]	Production[2] (metric tons)	Percentage of production	Yearend stocks[2] (metric tons)
Sphagnum moss	9	66,900	11	1,790
Hypnum moss	5	26,100	4	691
Reed-sedge	17	525,000	83	91,000
Humus	8	10,300	2	6,980
Total	38	628,000	100	100,000

[1] Some plants produce multiple types of peat; may not add to totals shown.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 5
U.S. PEAT SALES BY PRODUCERS IN 2010 BY TYPE AND USE[1]

	Sphagnum moss			Hypnum moss			Reed-sedge		
	Quantity			Quantity			Quantity		
Use	Weight (metric tons)	Volume[2] (cubic meters)	Value (thousands)	Weight (metric tons)	Volume (cubic meters)	Value (thousands)	Weight (metric tons)	Volume (cubic meters)	Value (thousands)
Earthworm culture medium	186	410	2	2,180	4,000	$52	2,290	5,050	$51
General soil improvement	52,500	328,000	2,200	1,910	3,500	58	53,900	113,000	835
Golf courses	9,590	65,000	580	--	--	--	6,950	30,000	670
Ingredient for potting soils	2,910	15,000	216	898	2,130	34	453,000	916,000	9,210
Mixed fertilizers	--	--	--	272	500	13	--	--	--
Nurseries	408	2,000	16	272	750	13	2,310	10,300	151
Packing flowers, plants, shrubs, etc.	--	--	--	--	--	--	--	--	--
Seed inoculant	--	--	--	--	--	--	3,410	11,200	280
Vegetable growing	8	23	--	--	--	--	1,400	2,580	33
Other	--	--	--	2,100	4,620	69	--	--	--
Total	65,600	410,000	3,010	7,620	15,500	239	523,000	1,090,000	11,200

	Humus			Total		
	Quantity			Quantity		
	Weight (metric tons)	Volume (cubic meters)	Value (thousands)	Weight (metric tons)	Volume (cubic meters)	Value (thousands)
Earthworm culture medium	308	504	$8	4,960	9,960	$114
General soil improvement	2,670	4,910	32	111,000	449,000	3,120
Golf courses	218	400	2	16,800	95,400	1,250
Ingredient for potting soils	4,690	8,620	206	461,000	941,000	9,670
Mixed fertilizers	--	--	--	272	500	13
Nurseries	650	1,210	27	3,650	14,300	207
Packing flowers, plants, shrubs, etc.	272	500	3	272	500	3
Seed inoculant	272	500	3	3,680	11,700	283
Vegetable growing	--	--	--	1,410	2,600	33
Other	--	--	--	2,100	4,620	69
Total	9,080	16,600	281	605,000	1,530,000	14,800

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Volume of nearly all sphagnum moss was measured after compaction and packaging.

TABLE 6
AVERAGE DENSITY OF DOMESTIC PEAT SOLD IN 2010

(Kilograms per cubic meter)[1]

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus
Bulk	218	664	634	719
Packaged	168	593	571	678
Bulk and packaged	209	643	629	713

[1] To convert kilograms per cubic meter to pounds per cubic yard multiply by 1.685.

TABLE 7
PRICES FOR PEAT IN 2010[1]

(Dollars per unit)

	Sphagnum moss	Hypnum moss	Reed-sedge	Humus	Average
Domestic:					
Bulk:					
Per metric ton	43.35	30.66	21.78	31.20	24.28
Per cubic meter	9.45	20.36	13.81	22.30	12.87
Packaged or baled:					
Per metric ton	61.79	33.07	17.62	29.33	26.48
Per cubic meter	10.36	19.62	10.06	19.87	10.58
Average:					
Per metric ton	45.95	31.32	21.48	30.81	24.39
Per cubic meter	9.61	20.14	13.50	21.98	12.62
Imported, total, per metric ton[2]	XX	XX	XX	XX	237.11

XX Not applicable.

[1] Prices are free on board plant.

[2] Average customs value.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF PEAT, BY COUNTRY[1]

	2009		2010	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Belgium	749	$95	911	$228
Bulgaria	148	16	--	--
Chile	--	--	142	117
Canada	871,000	218,000	921,000	232,000
Estonia	1,580	361	1,570	598
Finland	781	317	469	208
France	155	52	--	--
Germany	315	69	439	157
Ireland	1,690	514	1,900	902
Latvia	21,200	6,300	16,800	7,490
Lithuania	175	36	158	75
Netherlands	585	174	1,380	523
New Zealand	201	118	138	59
Norway	6,690	3,350	361	1,700
Sweden	1,190	298	1,220	634
United Kingdom	--	--	190	108
Other	230 [r]	171 [r]	196	148
Total	906,000	230,000	947,000	225,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Customs value.

Source: U.S. Census Bureau.

TABLE 9
PEAT: WORLD PRODUCTION, BY COUNTRY[1,2]

(Thousand metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Argentina, horticultural use	15	14	10	7 [r]	7
Australia[e]	7	7	7	7	7
Belarus:					
Horticultural use[e]	100	100	100	272 [r,4]	242 [4]
Fuel use	2,125	2,507	2,500	2,216 [r]	2,352 [4]
Total	2,225	2,607	2,600	2,488 [r]	2,593 [4]
Burundi, fuel use	10	7	10	11 [r]	12
Canada, horticultural use	1,245	1,282	1,151	1,131	1,262 [p,4]
Denmark, horticultural use[e]	262 [r]	213 [r,4]	128 [r]	128 [r]	128
Estonia:					
Horticultural use	1,207	964	705	110 [r]	361 [4]
Fuel use	507	475	213	419 [r]	604 [4]
Total	1,714	1,439	919	529 [r]	965 [4]
Finland:					
Horticultural use	6,919 [r]	8,671 [r]	6,933 [r]	5,576 [r]	5,580
Fuel use	896 [r]	1,145 [r]	1,552 [r]	876 [r]	880
Total	7,815 [r]	9,816 [r]	8,485 [r]	6,452 [r]	6,460
France, horticultural use[e]	200	200	200	200	200
Germany, horticultural use	218 [r]	85 [r]	119 [r]	119 [r]	119
Hungary, horticultural use[e]	77 [4]	90	90	90	107 [4]
Ireland:[5]					
Horticultural use[e]	500	500	500	500	500
Fuel use	3,800	2,700 [r]	3,000 [r]	2,800 [r]	2,800
Total	4,300	3,200 [r]	3,500 [r]	3,300 [r]	3,300
Latvia, horticultural and fuel uses	931	1,000 [e]	1,000	1,164 [r]	1,119 [4]
Lithuania, horticultural and fuel uses	471 [r]	307 [r]	521 [r]	543 [r]	327 [4]
Moldova, fuel use[e]	475	475	475	475	475
New Zealand, horticultural use[e]	27	27	27	26	26
Norway, horticultural use	69 [r]	140 [r]	438 [r]	440 [r,e]	440
Poland, horticultural and fuel uses	577 [e]	641	632 [r]	594 [r]	672 [4]
Russia, horticultural and fuel uses	1,400	1,300	1,300	1,300 [e]	1,300
Spain[e]	60	60	60	60	60
Sweden:[e]					
Horticultural use	1,511 [r,4]	1,500 [r]	1,130 [r]	1,230 [r]	1,230
Fuel use	2,995 [r,4]	2,640 [r]	1,320 [r]	1,320 [r]	1,320
Total	4,506 [r,4]	4,140 [r]	2,450 [r]	2,550 [r]	2,550
Ukraine, horticultural and fuel uses	462	395	358	691 [r]	597 [4]
United Kingdom	1	1	1	1	1
United States, horticultural use	551	635	615	609	628 [4]
Grand total	27,600 [r]	28,100 [r]	25,100 [r]	22,900 [r]	23,400
Of which:					
Horticultural use	12,900 [r]	14,400 [r]	12,100 [r]	10,400 [r]	10,800
Fuel use	10,800 [r]	9,950 [r]	9,070 [r]	8,120 [r]	8,440
Unspecified	3,910 [r]	3,710 [r]	3,880 [r]	4,360 [r]	4,080

[e]Estimated. [p]Preliminary. [r]Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 8, 2011. One cubic meter equals 0.8806 metric ton.

[3] In addition to the countries listed, Austria, Chile, Iceland, Italy, and Romania produced negligible amounts of peat.

[4] Reported figure.

[5] Fiscal year data.

PERLITE

By Wallace P. Bolen

Domestic survey data and tables were prepared by Joseph M. Krisanda, industry data analyst, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, the amount of domestic processed crude perlite sold or used increased by 19% and the amount of expanded perlite sold or used increased by 7% compared with those of 2009. Domestic production of processed crude perlite was 414,000 metric tons (t), and the amount of expanded perlite sold or used was 471,000 t. Domestically produced processed crude perlite sales increased after a 20% decrease in 2009. The 414,000 t sold or used was about the same amount sold or used in 2007, when 409,000 t was produced. While it was an improvement, the amount of expanded perlite sold or used in 2010 was still the second lowest quantity sold or used since 1991, when 449,000 t were sold or used.

During the year, imports of processed crude perlite increased by 14% to 174,000 t compared with those of 2009. This increase in perlite imports followed 3 consecutive years with declining imports after a record-high import level in 2006. Exports of crude processed perlite were estimated to have been about 42,000 t in 2010, increasing by about 27% compared with those of 2009. Trade data in this report are from the U.S. Census Bureau and PIERS, a U.S. trade database compiled by the Journal of Commerce. Percentages in this report were computed using unrounded data.

Production

Domestic production data for perlite were compiled by the U.S. Geological Survey (USGS) from two voluntary annual surveys—one for domestic mine operations (processed crude perlite) and one for expanding plants. The expanding plants used domestic and imported processed crude perlite. All the processed crude perlite described in table 1 was produced by seven companies with nine mines, eight of which responded to the USGS survey, representing more than 99% of the processed crude perlite sold or used in 2010. According to data collected by the USGS, the 414,000 t of U.S.-processed crude perlite sold or used in 2010 was valued at $21.6 million. This was an increase of 19% in tonnage and a 27% increase in value compared with those of 2009. The 471,000 t of expanded perlite sold or used by domestic producers was valued at $143 million. Sales and use increased by 7%, and value increased by 8% compared with those of 2009 (table 1).

The processed crude perlite reported in table 1 was mined in Arizona, California, Idaho, Nevada, New Mexico, and Oregon. The mines in Arizona, New Mexico, and Oregon accounted for most of the tonnage mined. Ore producers were, in alphabetical order by State, Harborlite Corp. in Arizona and New Mexico; American Perlite Co. in California; Idaho Minerals, LLC in Idaho; EP Minerals, LLC and Wilkins Mining and Trucking, Inc. in Nevada; Dicaperl Minerals Corp. in New Mexico; and Cornerstone Industrial Minerals Corp. in Oregon.

Perlite was expanded at 50 plants throughout the United States and 3 plants were reported as idle. Several of the larger expanding plants were idled in 2010 owing to decreased demand for construction-related products. Production was consolidated at other locations until demand increases. One perlite expander in New Jersey was idle while the company rebuilt after a fire destroyed much of the facility. Two smaller volume expanding operations were thought to have shut down permanently. Of the 50 active plants, 28 plant operators (56%) responded to the USGS survey, representing about 81% of the total expanded perlite sold or used. Production information for nonresponding companies was estimated using previously reported data, with adjustments based on currently reported production trends. The top seven producers of expanded perlite, each with production of more than 20,000 metric tons per year, accounted for about 80% of the expanded perlite sold or used in the United States in 2010. The remaining 20% was produced by 19 companies.

Consumption

In 2010, domestic apparent consumption of processed crude perlite was 546,000 t, a 17% increase compared with that of 2009. The average level of apparent consumption in 2009 and 2010 was the lowest since 1991, which was also a recessionary period in the United States.

Beginning with this report, an "unspecified" use category is listed in table 3. This category includes estimated and reported quantities of expanded perlite where the consuming market was unknown. For comparison, 2009 data were revised to include this category. Much of these data were previously reported in the "Other" category in recent USGS perlite reports, and, therefore, that category was revised for 2009 as well.

Expanded perlite consumed for construction-related uses, the major market for expanded material, was about 260,000 t, an increase of 12% compared with that of 2009. Construction uses of expanded perlite, which consisted of concrete aggregate, formed products, masonry- and cavity-fill insulation, and plaster aggregate, accounted for about 55% of total domestic sales of expanded perlite in 2010. Expanded perlite consumption increased in six markets, with the most pronounced increases by percentage reported for the concrete aggregates market (table 3). Expanded perlite consumption decreased significantly in two of the smaller markets: masonry- and cavity-fill insulation and plaster aggregate.

Perlite was expanded, usually for local consumption, in 26 States. The leading States in production of expanded perlite sold or used were, in descending order, Illinois, Georgia, Pennsylvania, Minnesota, Mississippi, Michigan, California, Oregon, and Florida. The amount of expanded perlite sold or used by State was listed for those States with three or more companies expanding in each State; for other States, individual data were withheld to avoid disclosing company proprietary data (table 2).

Prices

Processed crude perlite was sold at an average value of $52 per metric ton, which was a 4% increase compared with that of 2009. Perlite consumed by expanding plants operated by the mining companies was valued at $54 per ton, which was a 15% increase compared with that of 2009. The average value for all perlite sold or used by mining companies was $52 per ton, which was a 6% increase compared with that of 2009. The average value of expanded perlite was $304 per ton, up slightly from $302 per ton in 2009. The range in reported prices, however, was wide—from about $100 per ton to more than $1,000 per ton.

The average value of expanded perlite by use, in descending order, was low-temperature insulation, $559 per ton; masonry- and cavity-fill insulation, $469 per ton; fillers, $459 per ton; horticultural aggregate, $446 per ton; plaster aggregate, $403 per ton; filter aid, $399 per ton; concrete aggregate, $378 per ton; high-temperature insulation, $281 per ton; and formed products, $198 per ton (table 3).

Foreign Trade

Exports of processed crude and expanded perlite, primarily to Canada, were estimated to be 42,000 t, up by about 27% compared with those of 2009. Most of the perlite exported to Canada was horticultural grade perlite and is commonly mixed with peat and other ingredients to produce potting soils. Canada has abundant peat resources and is a leading producer of potting soils. The Republic of Korea was probably the second largest recipient of U.S. exports, receiving nearly 9,000 t. Perlite was exported to approximately 30 other countries, but the average amount exported to each of those countries was less than 1,000 t. The value of exports could not be calculated based on available information, but the average prices quoted previously could be applied.

Imports of processed crude perlite, almost exclusively from Greece, increased by 14% to 174,000 t compared with those of 2009. S&B Industrial Minerals S.A., Kifissia, Greece, was the primary supplier of processed crude perlite imports to the United States. Based on information from the U.S. Census Bureau, the average customs value of perlite imports in 2010 was estimated to be $102 per ton, a slight decrease from that of 2009. If insurance and freight costs ($11.15 per ton) were added to the value of the imports, the total average value of imports was $113 per ton, a decrease of about 3% compared with the total average value in 2009. These decreases in the price of imported perlite were probably in response to lower demand amid strong competition during 2010. Most imported perlite arrives through the ports of Brunswick, GA; Mobile, AL; Philadelphia, PA; and Wilmington, DE. After arriving at one of these ports, the perlite is shipped to expanding plants throughout the States east of the Mississippi River.

World Review

Based on available information, the United States was estimated to be the leading consumer of processed crude and expanded perlite in 2010. Greece was estimated to have produced about 500,000 t and sold or used the largest amount of perlite among the countries listed in table 4. Other leading producers of processed crude perlite were, in descending order, the United States, Turkey, and Japan. In 2010, 15 countries produced 1.67 million metric tons of perlite, a slight increase compared with global production in 2009. Owing to a lack of reliable information, however, this total does not include all major producing countries, such as China, which was probably the leading or second ranked producer in the world.

Outlook

Total consumption of processed and expanded perlite in the United States in 2011 was expected to remain around the relatively low levels of 2010. With the economic recession, which was characterized by lackluster construction activity, including the continuing slump in housing and office construction, the perlite consumption amounts seen in 2010 are expected to continue. Perlite imports in 2011 were expected to be essentially unchanged from 2010 levels. Prices for crude processed perlite increased in 2010, but prices for expanded perlite were essentially flat compared with 2009 prices. For 2011, market conditions were expected to be conducive for prices of crude processed perlite and expanded perlite to remain near 2010 levels. Price increases might be difficult to achieve amidst weak demand and strong competition.

Perlite expanding plants, mostly in the Eastern United States, continued to purchase imported perlite and offer strong competition to domestic perlite producers. Imported perlite has supplied about one-quarter of the demand for processed crude perlite in the United States during the past 3 years, and that trend is expected to continue contingent upon the availability and cost of ocean freight. This strong competition from other countries is expected to continue in the coming years as domestic and foreign suppliers fight for market share amidst fluctuating transportation costs, whether rail or ocean freight.

GENERAL SOURCES OF INFORMATION

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TABLE 1

PERLITE MINED, PROCESSED, AND EXPANDED IN THE UNITED STATES[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2006	2007	2008	2009	2010
Perlite mined[2]		516	516	524	304	529
Processed crude perlite:						
Sold to expanders:						
Quantity		360	324	337	263	319
Value		15,600	15,000	16,400	13,100	16,500
Average value	dollars per metric ton	43	46	49	50	52
Used at own plants to make expanded perlite:						
Quantity		95	85	98	85	95
Value		3,850	3,550	4,450	4,000	5,090
Average value	dollars per metric ton	41	42	46 r	47	54
Total, sold and used:						
Quantity		454	409	434	348	414
Value		19,500	18,500	20,800	17,100	21,600
Average value	dollars per metric ton	43	45	48	49	52
Expanded perlite:						
Production, quantity		646	577	554	450	472
Sold or used:						
Quantity		644	575	548	439	471
Value		165,000	155,000	153,000	132,000	143,000
Average value	dollars per metric ton	256	269	279	302	304

r Revised.

[1] Data are rounded to no more than three significant digits, except average value; may not add to totals shown.

[2] Crude ore mined and stockpiled for processing.

TABLE 2

EXPANDED PERLITE PRODUCED AND SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

	2009				2010			
		Sold or used				Sold or used		
State	Production, quantity (metric tons)	Quantity (metric tons)	Value (thousands)	Average value[2] (dollars per metric ton)	Production, quantity (metric tons)	Quantity (metric tons)	Value (thousands)	Average value[2] (dollars per metric ton)
California	29,100	28,700	$10,800	377 r	27,500	27,300	$10,400	379
Florida	21,300	21,000	7,120	338	24,900	24,700	8,250	334
Indiana	12,900	12,800	4,710	369	W	W	W	W
Michigan	21,800	21,200	5,460	258	27,900	28,100	6,880	245
Nevada	11,100	11,100	4,980	448	12,600	12,400	5,920	476
Pennsylvania	47,700	47,700	11,200	235	52,600	52,600	12,300	233
Other[3]	306,000	296,000	88,100	297 r	327,000	326,000	99,300	305
Total or average	450,000	439,000	132,000	302	472,000	471,000	143,000	304

r Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Average value is based on unrounded data and is rounded to the nearest dollar.

[3] Includes Alabama (2009), Arizona, Arkansas, Colorado, Georgia, Idaho, Illinois, Indiana (2010), Louisiana, Maine, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey (2009), North Carolina, Ohio, Oklahoma, Oregon, Tennessee, Texas, Wisconsin, and Wyoming.

TABLE 3

EXPANDED PERLITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2009			2010		
	Quantity (metric tons)	Value (thousands)	Average value[2] (dollars per metric ton)	Quantity (metric tons)	Value (thousands)	Average value[2] (dollars per metric ton)
Concrete aggregate	2,440	$973	398	3,910	$1,480	378
Fillers	62,700	28,900	461	67,900	31,200	459
Filter aid	37,200	14,500	391	41,700	16,700	399
Formed products[3]	222,000	43,200	195	251,000	49,700	198
High-temperature insulation	6,320	1,830	290	7,430	2,090	281
Horticultural aggregate	63,800 [r]	27,100	425 [r]	65,300	29,100	446
Low-temperature insulation	1,990	1,110	559	1,910	1,060	559
Masonry- and cavity-fill insulation	2,610	1,190	457 [r]	1,730	810	469
Plaster aggregate	4,880	1,720	352	3,010	1,210	403
Other[4]	2,630 [r]	678 [r]	258 [r]	1,740	444	255
Unspecified[5]	32,100	11,100	347	25,000	9,310	373
Total or average	439,000	132,000	302	471,000	143,000	304

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Average value is based on unrounded data and is rounded to the nearest dollar.

[3] Includes acoustic ceiling panels, pipe insulation, roof insulation board, and unspecified formed products.

[4] Includes absorbents, laundries, paint texturizers, and other miscellaneous uses.

[5] Estimated and reported data with specific use unknown.

TABLE 4

PERLITE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010
Armenia	35,000	35,000	35,000	35,000	35,000
Australia[4]	6,500	7,000	7,000	6,500	7,000
Georgia	45,000	45,000	45,000	45,000	45,000
Greece[5]	525,000	525,000	525,000	525,000	500,000
Hungary[4]	71,000	67,000	67,000	65,000	65,000
Iran	40,000	30,000	30,000	30,000	20,000
Italy	60,000	60,000	60,000	60,000	60,000
Japan	240,000	230,000	230,000	220,000	210,000
Mexico[4]	41,219 [6]	54,405 [r, 6]	43,180 [r, 6]	51,395 [r, 6]	50,000
Philippines	4,352 [6]	4,515 [6]	4,593 [6]	4,606 [r, 6]	4,600
Slovakia	16,000	20,000	25,000	25,000	25,000
South Africa	400	400	400	400	400
Turkey[4]	260,000	270,000	270,000	230,000	230,000
United States[6, 7]	454,000 [r]	409,000 [r]	434,000 [r]	348,000 [r]	414,000
Zimbabwe	3,000	3,000	3,000	3,000	2,000
Total	1,800,000	1,760,000 [r]	1,780,000 [r]	1,650,000	1,670,000

[r] Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Unless otherwise stated, figures represent processed ore output. Table contains data available through May 26, 2011.

[3] In addition to the countries listed, Djibouti started perlite production in 2009, and Algeria, Bulgaria, China, Cyprus, Iceland, Morocco, Mozambique, and Russia are thought to have produced perlite, but output is not reported, and available information is inadequate to estimate output.

[4] Crude ore.

[5] Crude perlite screened and sold.

[6] Reported figure.

[7] Processed ore sold and used by producers.

PHOSPHATE ROCK

By Stephen M. Jasinski

Domestic survey data and tables were prepared by Raymond I. Eldridge III, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

World phosphate markets rebounded in 2010, returning to consumption levels of 2008 before the global economic downturn that affected fertilizer markets. Domestic phosphate rock production in 2010 was 25.8 million metric tons (Mt) compared with 26.4 Mt in 2009 owing to producers significantly drawing down stocks of phosphate rock. Reported domestic use of phosphate rock was 28.1 Mt compared with 25.5 Mt in 2009 (tables 1, 3, 4) as production of phosphoric acid and ammonium phosphates increased in 2010. World production was 12% higher than that in 2009 (table 10) owing to market rebound from the global economic downturn and increasing demand for fertilizer in China and India. Phosphorus is an essential element for plant and animal nutrition and is consumed primarily as a principal component of nitrogen-phosphorus-potassium (NPK) fertilizers. Phosphate rock minerals are the only significant global resources of phosphorus. In this report (unless noted otherwise), mine production is reported in terms of marketable production, which refers to beneficiated phosphate rock with a suitable phosphorus pentoxide (P_2O_5) content for wet-process phosphoric acid or elemental phosphorus manufacturing. Quantities are reported in metric units and percentages have been calculated using unrounded data.

Domestic production of all types of phosphoric acid in 2010 increased to 9.41 Mt P_2O_5 from 8.66 Mt in 2009. Phosphate acid production for fertilizer use increased to 8.72 Mt P_2O_5 compared with 8.01 Mt in 2009. Combined production of all types of phosphate fertilizers was 12% higher than in 2009 because of increased production of monoammonium phosphate (MAP) (U.S. Census Bureau, 2011). The major fertilizer products manufactured from phosphoric acid were diammonium phosphate (DAP) and MAP.

Production

U.S. Geological Survey domestic phosphate rock production data were obtained from monthly and semiannual voluntary canvasses of all companies that owned phosphate rock mines. All companies responded to the canvass. In 2010, phosphate rock was produced at seven mines in Florida, three in Idaho, and one each in North Carolina and Utah (table 2).

The U.S. phosphate industry is concentrated in Florida in the counties of Hamilton, Hardee, Hillsborough, Manatee, and Polk. In 2010, seven mines, representing 65% of domestic annual production capacity, were active in Florida. The Mosaic Company operated five mines, and CF Industries, Inc. and PCS Phosphate Co., Inc. each operated one mine (table 2).

Mosaic planned to use imported phosphate rock, primarily from a joint venture with Vale S.A. in Peru, at its Louisiana phosphate plants (Mosaic Company, The, 2011, p. 2). According to U.S. Census Bureau statistics, Mosaic imported 183,000 metric tons (t) of phosphate rock from Peru in 2010.

Mosaic was forced to close temporarily its South Fort Meade Mine from early September to early December after a July 30, 2010, preliminary injunction by the U.S. District Court for the Middle District of Florida. The injunction stemmed from a lawsuit filed by the Sierra Club and other environmental groups in Florida challenging the Army Corps of Engineers permit approval for expansion of the mine into Hardee County. In late October, Mosaic reached an agreement with the environmental groups to allow the company 4 months to mine about 80 hectares (ha) of the 4,280 ha of the extension into Hardee County. Mosaic mined the area from December 2010 to March 2011. Mosaic increased production at its other mines and used imported phosphate rock from Morocco and Peru as feedstock to its fertilizer plants to replace lost production from the South Fort Meade Mine in 2010 (Green Markets, 2010b).

In Beaufort County, NC, PCS operated a large integrated production facility that included a mine, as well as animal feed, fertilizer, and phosphoric acid plants.

In the Western Phosphate Field in Idaho, Montana, Utah, and Wyoming, four mines were active in 2010—three in Idaho and one in Utah (table 2). In Idaho, phosphate rock was mined in Caribou County by Nu-West Industries, Inc. (a subsidiary of Agrium Inc., Calgary, Alberta, Canada), P4 Production, L.L.C. (a subsidiary of Monsanto Co.), and J.R. Simplot Company. Simplot also operated the Vernal Mine in Uintah County, UT.

In Idaho, Agrium, P4 Production, and Simplot began development of new mines as replacements for their current operations to be used when the mines are exhausted. Simplot received approval for its mine expansion in December 2010 (J.R. Simplot Company, 2011). P4 Production submitted plans to spend an additional $10 million in environmental safeguards at its Blackfoot Bridge Mine that was under development in the Caribou/Targhee National Forest in Idaho (Green Markets, 2010a). Agrium was in the initial stages of development of its new mine, and Federal and State agencies were planning to commence work on an environmental impact statement in 2011 (U.S. Bureau of Land Management, 2011).

Consumption

Phosphate rock was used primarily for production of wet-process phosphoric acid for fertilizer applications, which accounted for more than 90% of domestic consumption. The remainder was used in the manufacturing of animal feed supplements, for direct application to soil, and for elemental phosphorus production. Domestic consumption of phosphate rock was 30.5 Mt compared with 27.5 Mt in 2009 (table 1), owing to the improved market conditions. There were no sales of domestically mined phosphate rock reported by producers. Consumption by grade and by region was withheld from publication to avoid disclosing company proprietary information.

All phosphate rock mining companies are vertically integrated, having one or more fertilizer plants, usually located near the mine. Mosaic was the leading company with about 56% of domestic phosphoric acid production capacity and 13% of world capacity. In 2010, the company operated four wet process phosphoric acid plants and four fertilizer plants in Florida and one of each in Louisiana (Mosaic Company, The, 2011, p. 1).

PCS had phosphoric acid and fertilizer production facilities near its mines in Florida and North Carolina. In Idaho, Simplot sent ore from its Smoky Canyon Mine by slurry pipeline to its fertilizer plant in Pocatello, ID; Simplot sent ore by pipeline from the Vernal Mine in Utah to its plant in Rock Springs, WY.

Three companies—Agrifos Fertilizer Inc., Pasadena, TX; Mississippi Phosphates Corp., Pascagoula, MS; and PCS Nitrogen, Inc., Geismar, LA—manufactured wet-process phosphoric acid using imported phosphate rock from Morocco. Agrifos and Mississippi Phosphates produced phosphate fertilizer products for domestic and export markets. PCS sold some merchant-grade phosphoric acid to Innophos Holdings, Inc., which had a nearby facility, for upgrading into high-purity acid for technical- and food-grade applications (Innophos Holdings, Inc., 2011, p. 8).

Monsanto operated the only elemental phosphorus plant in the United States in Soda Springs, ID. The company used elemental phosphorus to manufacture phosphorus trichloride, which was used as a chemical intermediary for the production of glyphosate-base herbicides (Monsanto Company, 2010, p. 7). In other countries, elemental phosphorus was used chiefly to manufacture high-purity phosphoric acid by burning the phosphorus in water, which is known as thermal acid. Worldwide, there has been a gradual shift to manufacturing high-purity phosphoric acid from wet-process acid, which has lower operating costs and none of the hazardous waste disposal issues that are associated with elemental phosphorus. Thermal acid, however, still accounts for 65% of annual world production capacity of high-purity phosphoric acid, primarily in China. The only other operating elemental phosphorus facilities in the world were located in China, Kazakhstan, and the Netherlands.

The United States is considered a mature market for phosphate fertilizers, with average annual consumption of slightly more than 4.0 Mt during the past decade. Fertilizer consumption information is collected by the American Association of Plant Food Officials on a crop year (July 1 to June 30) basis. The most recent data, for crop year 2009 (July 1, 2008, to June 30, 2009), showed a 25% decrease in P_2O_5 consumed in fertilizers from the previous crop year, owing to the economic downturn that affected the global fertilizer industry (Slater and Kirby, 2011, p. 6). Consumption of P_2O_5 contained in fertilizers was estimated to have increased in crop year 2010 because of fertilizer use and sales returning to near average levels.

Stocks

Producers' stocks of phosphate rock on December 31, 2010, were 31% lower than in yearend 2009 (table 3).

Transportation

In Florida and North Carolina, crude phosphate rock ore was sent by slurry pipeline from the mines to the processing plants. All beneficiated phosphate rock was used internally to manufacture wet-process phosphoric acid; the beneficiated phosphate rock was sent by conveyers to acid plants. Mosaic sent some beneficiated phosphate rock by rail to the Port of Tampa and ore by barge across the Gulf of Mexico to its facilities in Louisiana. However, since the company stopped sending rock from its mines in Florida to Louisiana, after it began receiving phosphate rock from Peru in August 2010. In central Florida, animal feed products, fertilizers, and phosphoric acid were sent by rail to domestic customers or to the Port of Tampa for export. The Port of Tampa handles the largest volume of fertilizer materials in the United States.

In northern Florida, PCS transported its fertilizer products by rail to consumers; some materials, however, were sent by rail to the PCS port facility at Morehead City, NC, for export. PCS used barges and tugboats to move products from its Aurora, NC, complex to the Port of Morehead City for export or delivery by rail to domestic consumers. Phosphoric acid producers along the Gulf of Mexico received phosphate rock by ship from Morocco and transported their products by barge on the Mississippi River and its tributaries or by rail to domestic consumers. In Idaho and Utah, phosphate rock was sent from the mine to the processing facility via truck, rail, and slurry pipelines.

Prices

Price data were collected through the semiannual canvass of producers and reflected the value of phosphate rock used for production of phosphoric acid and elemental phosphorus. The total value of phosphate rock used in the United States decreased by 32% from that of 2009 owing to a return to lower prices because of the economic downturn that began in late 2008 after the prices had spiked (table 1). Unlike many other mineral commodities, no standard domestic or world price for phosphate rock exists. Average ranges of world prices were published in various industry trade journals based on a sample of transactions. The import price of $87.79 per metric ton was determined based on the U.S. Census Bureau customs value and included cost, insurance, and freight (table 1).

Foreign Trade

U.S. producers reported no exports of phosphate rock in 2010 (table 1). The United States is the leading importer of phosphate rock in the world. More than 90% of imported phosphate rock was from Morocco and all imported phosphate rock was consumed by phosphoric acid producers located along the Gulf of Mexico—Agrifos, Mississippi Phosphates, Mosaic, at its Louisiana plants, and PCS Nitrogen. In 2010, U.S. imports were estimated to be 2.4 Mt, based on data from the U.S. Census Bureau and PIERS, a commercial database reporting on waterborne trade activity. Tonnage and value information for some phosphate rock and fertilizer product shipments were underreported by the U.S. Census Bureau, which necessitated the use of other sources. U.S. import tonnage of other phosphate ertilizers was insignificant compared with exports of the same materials (tables 5–7, 9).

The United States is the leading exporter of phosphate ertilizers in the world, accounting for about 25% of world P_2O_5 ontained in processed phosphate exports in 2010. In total, xports of phosphoric acid and phosphate fertilizers decreased y 9%, in terms of P_2O_5 content (U.S. Census Bureau, 2011). ndia was the leading destination for U.S. phosphate exports tables 5–7).

World Review

World production of phosphate rock increased by 12% n 2010 compared with that of 2009. China (68.0 Mt), the United States (25.8 Mt), and Morocco (25.8 Mt) were the eading producing countries, accounting for 66% of the world otal (table 10). Phosphate rock production in China likely was higher than the official figure of 68.0 Mt, which did not nclude production from numerous, small independent mines. Information was not available to estimate production from these operations. Much of the activity in phosphate rock exploration and expansion took place in Africa and Australia in 2010. In addition to major projects in Africa (Morocco and Namibia), smaller mines were under various stages of development in Angola, Mali, Mauritania, Mozambique, Uganda, and Zambia. Expansion of production capacity was planned in Egypt, Senegal, South Africa, Tunisia, and Togo. Phosphate rock production began in Saudi Arabia in late 2010; however, the rock was being stockpiled until the associated phosphate plant began operation in 2011 (Ma'aden Phosphate Co., 2010).

Australia.—Four major phosphate projects were under development in Australia in 2010, three in the Northern Territory and one in Queensland. The largest of the four, the Wonarah Rock Phosphate project located near Tennant Creek, Northern Territory, reported significant progress in 2010, according to Minemakers Ltd. (Minemakers Ltd., 2010, p. 2). The company completed the first stage of the project, a feasibility study for a direct-shipping ore operation, which could start by late 2011, depending on the phosphate rock prices. The second stage would involve construction of a beneficiation plant, and stage three would be construction of a rail spur to the main railway to the Port of Darwin. A feasibility study has yet to be started for the stages 2 and 3. In July 2010, Minemakers signed an investment agreement with JDCPhosphate, Inc. of Florida, which has developed a dry kiln technology for producing superphosphoric acid. Minemakers would be granted the exclusive Australian license to use the JDC process at Wonarah plant. Total reported indicated and inferred resources at the Wonarah project were 1,258 Mt grading of 12% P_2O_5, with an Australasian Joint Ore Reserves Committee (JORC)-compliant indicated resource of 399 Mt grading 21% P_2O_5, with a cutoff grade of 15% P_2O_5 (Fertilizer International, 2010d).

Legend International Holdings, Inc. reported completion of a feasibility study by Wengfu Group Ltd. of China for the Paradise Phosphate Project in Queensland. The project included the Paradise North and Paradise South Mines and a processing facility at Mt. Isa. Legend planned to start mining at Paradise North in 2013 at a rate of 1.25 million metric tons per year (Mt/yr) of marketable rock, with an average grade of 29.5% P_2O_5. The ore would be beneficiated by dry screening to remove silica and sent by truck to a phosphate fertilizer complex, which would be constructed at Mt. Isa. The fertilizer complex would include production facilities for sulfuric acid, phosphoric acid, ammonium phosphates, and aluminum fluoride. Legend planned to start mining the Paradise South deposit in 2017 at a rate of 2.5 Mt/yr. The ore would be processed at an onsite flotation plant before being sent to Mt. Isa. The company reported total JORC-compliant indicated resources at 392 Mt, grading 15.7% P_2O_5. The company expected to begin operating in 2013 (Fertilizer International, 2010b).

Korab Resources Ltd. (through its subsidiary GeolSec Phosphate Operations Pty. Ltd.) was developing a phosphate rock deposit near Rum Jungle in the Northern Territory. The company planned to market the phosphate rock for direct application to soil for organic farming. The phosphate rock would be mined by simple quarrying and processed by crushing and grinding. GeolSec planned to start production in 2011 at a rate of 15,000 metric tons per year (t/yr), increasing to 30,000 t/yr in 2013. The total resources of the deposit were estimated to be 1.3 Mt with an average grade of 12% P_2O_5 (Fertilizer International, 2010a).

In the other project in the Northern Territory, phosphate rock would be recovered as a byproduct of rare-earth processing. The Arafura Resources Ltd.'s, Nolans Bore project, located 135 kilometers northwest of Alice Springs, had resources of 3.9 Mt of phosphate rock, with and an average grade of 12.9% P_2O_5, in addition to 848,000 t of rare-earth oxides, and 6,000 t of uranium. The company planned to start production in 2013 (Fertilizer International, 2010e).

Brazil.—Vale, through its wholly owned subsidiary Mineracao Naque SA, consolidated its position as the leading fertilizer producer in Brazil through the acquisition of the fertilizer assets of three other producers in Brazil: Bunge Participacoes e Investimentos S.A. (Bunge Ltd.), Fertilizantes Fosfatodos S.A. (Fosfertil), and some assets held by Yara International ASA of Norway. Included in the transaction were Bunge's two phosphate rock mines and the associated phosphoric acid plants. Vale also obtained the Anitapolis phosphate rock mine project that was owned by Bunge and Yara. Vale gained a controlling interest in Fosfertil, which included three phosphate rock mines (Fertilizer Week America, 2010a).

Canada.—Agrium expected its Kapuskasing, Ontario, phosphate rock mine to be depleted in 2013. The company was in negotiations to establish a long-term supply contract for its Redwater, Alberta, phosphate operations, probably with an overseas supplier (Agrium Inc., 2011, p. 22).

Morocco.—OCP Group, the Moroccan phosphate producer, announced plans to expand its phosphate rock and fertilizer production capacity incrementally during a 7-year period beginning in 2011. OCP planned to increase annual phosphate rock mine production capacity from 30 Mt/yr to 50 Mt/yr, increase beneficiation capacity from 9 Mt/yr to 38 Mt/yr, increase DAP/MAP capacity from 3 Mt/yr to 9 Mt/yr, and expand the port facility at Jorf Lasfar to handle up to 38 Mt/yr of phosphate products. The expansion of the DAP and MAP capacity was to be done through the construction of four new plants at Jorf Lasfar, each with an annual production capacity of 1 Mt/yr of combined DAP and MAP. The plants were planned to be built at 6-month intervals between 2013 and 2015. In the first quarter of 2013, OCP expected to start building a 44-Mt/yr slurry pipeline to transport phosphate rock from the mines to the new and existing phosphate plants at Jorf Lasfar. Upon completion of all projects, Morocco will be the world's leading supplier of phosphate rock, phosphoric acid, DAP, and MAP (Fertilizer Week, 2010).

Namibia.—Marine Phosphate (Pty.) Ltd. (a joint venture between Minemakers, Tungeni Africa Investments cc, and Union Resources Ltd.) completed a scoping study of Sandpiper/Meob offshore phosphate joint-venture project about 60 km offshore of Namibia at a depth of 225 meters. Initial indicated reserves are 73.9 Mt, with an average grade of 20.57% P_2O_5 and inferred reserves are 1,500 Mt, with an average grade of 18.7% P_2O_5. The company also planned to test the JDCPhosphate process with ore from Namibia. A feasibility study was planned for 2011 to determine if the project should produce phosphate rock, phosphoric acid, or both. Minemakers, which holds the largest share in the project, planned to start production in late 2013 (Fertilizer International, 2011).

Peru.—Vale of Brazil began production at its Miski Mayo Mine phosphate rock mine in the Sechura Desert in the Piura region of northwestern Peru. Production was expected to increase gradually from the initial production capacity of 1 Mt/yr to full capacity of 3.9 Mt/yr during several years. The mine is operated by a subsidiary of Vale and is owned by a joint-venture agreement between Vale (40%), Mosaic (35%), and Mitsui & Co. of Japan (25%). Mosaic entered into the joint venture in March 2010, and it will receive up to 35% of production. The rock was to be shipped primarily to Brazil, Indonesia, and the United States. Vale was considering building a phosphate plant onsite before 2013, depending on market conditions (Fertilizer Week America, 2010b).

Stonegate Agricom Ltd. of Canada was developing the Mantaro Phosphate property located 250 km from Lima near Huancayo. The company planned to conduct a feasibility study in 2011 and start production in 2013. The company was still evaluating the total estimated reserves for the project (Fertilizer International, 2010c).

Outlook

World phosphate rock annual production capacity was projected to increase 26% from 2010 to 2015, increasing from 203 Mt to 256 Mt, with more than 50% of the increase from Africa. The increase will be from a combination of new mines and expansion of existing operations, some of which were discussed in the previous section. About 70% of the new capacity will be for the export market (Heffer and Prud'homme, 2011). U.S. production capacity will likely remain the same or decrease slightly through 2015 depending on whether three new mines under development in Florida are able to receive permits to operate. A new mine in Idaho was expected to be permitted, but it would be as a replacement for an existing mine.

The projected increases in annual production capacity for phosphate rock will supply the associated increase in phosphoric acid and fertilizer production. World population growth ensures the need for phosphate fertilizer to grow crops for food and biofuels. World consumption of P_2O_5 in fertilizer was projected to increase from 39.9 Mt in 2010 to 41.4 Mt in 2011 and to 44.9 Mt in 2015, according to the International Fertilizer Industry Association. Phosphoric acid production capacity was expected to increase by 3.9% per year between 2010 and 2015, with one-third of the new output from operations in China. Global production of phosphate fertilizer was expected to increase from 36.6 Mt/yr P_2O_5 to 44.4 Mt/yr P_2O_5 (Heffer and Prud'homme, 2011).

Domestic production and consumption of phosphate rock in 2011 were expected to be slightly higher than in 2010 as the fertilizer markets return to conditions seen before the economic downturn.

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TABLE 1

SALIENT PHOSPHATE ROCK STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2006	2007	2008	2009	2010
United States:						
Mine production (crude ore)		111,000	126,000	124,000	107,000	106,000
Marketable production:						
Quantity:						
Gross weight		30,100	29,700	30,200	26,400	25,800
P_2O_5 content		8,680	8,480	8,590	7,640	7,400
Value		919,000	1,520,000	2,320,000	3,360,000	1,980,000
Value, average[2]	dollars per metric ton	30.49	51.10	76.76	127.19	76.69
Sold or used by producers:						
Quantity:						
Gross weight		30,200	31,100	28,900	25,500	28,100
P_2O_5 content		8,710	8,890	8,200	7,380	8,000
Value		922,000	1,600,000	2,210,000	3,250,000	2,210,000
Value, average	dollars per metric ton	30.52	51.36	76.64	127.22	78.50
Imports for consumption[e, 3, 4]						
Quantity, gross weight		2,420	2,670	2,750	2,000	2,400
Value, cost, insurance, and freight[e]		115,000	154,000	266,000	161,000	211,000
Value, average	dollars per metric ton	47.52	57.54	96.95	80.61	87.79
Consumption, gross weight[e, 5]		32,600	33,500	31,600	27,500	30,500
Stocks, December 31, producers		7,070	4,970	6,340	8,120	5,620
World, production, gross weight		151,000	160,000	165,000	161,000 [r]	181,000 [e]

[e]Estimated. [r]Revised.

[1] Data are rounded to no more than three significant digits, except average values per metric ton.

[2] Average value based on the sold or used values.

[3] Source: U.S. Census Bureau.

[4] Includes some estimated phosphate rock tonnage imported from Morocco but not reported by the U.S. Census Bureau.

[5] Expressed as sold or used plus imports.

TABLE 2
ACTIVE PHOSPHATE ROCK MINES IN THE UNITED STATES IN 2010

Owner	Mine	County and State
CF Industries Holdings, Inc.	South Pasture	Hardee, FL.
Mosaic Company, The	Four Corners	Hillsborough/Manatee/Polk, FL.
Do.	Hookers Prairie	Polk, FL.
Do.	Hopewell	Hillsborough, FL.
Do.	South Fort Meade	Polk, FL.
Do.	Wingate	Manatee, FL.
Nu-West Industries, Inc. (Agrium Inc.)	Dry Valley	Caribou, ID.
P4 Production, LLC. (Monsanto Co.)	South Rasmussen	Do.
PCS Phosphate Co., Inc.	Aurora	Beaufort, NC.
Do.	Swift Creek	Hamilton, FL.
Simplot, J.R., Co.	Smoky Canyon	Caribou, ID.
Do.	Vernal	Uintah, UT.

Do. Ditto.

TABLE 3
PRODUCTION OF PHOSPHATE ROCK IN THE UNITED STATES, BY PERIOD[1]

(Thousand metric tons and thousand dollars)

	Mine production, crude ore		Marketable production, beneficiated			
Period	Rock	P_2O_5 content	Rock	P_2O_5 content	Value[2]	Ending stocks, rock
2009:						
January–June	53,800	5,430	12,900	3,730	2,500,000	9,100
July–December	53,200	5,470	13,500	3,910	858,000	8,120
Total	107,000	10,900	26,400	7,640	3,360,000	XX
2010:						
January–June	55,300	5,870	13,200	3,720	896,000	7,570
July–December	50,600	6,030	12,700	3,680	1,080,000	5,620
Total	106,000	11,900	25,800	7,400	1,980,000	XX

XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Based on the per ton sold or used values.

TABLE 4
PHOSPHATE ROCK SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY PERIOD[1]

(Thousand metric tons and thousand dollars)

Period	Rock	P_2O_5 content	Value[2]
2009:			
January–June	11,200	3,230	2,310,000
July–December	14,300	4,150	936,000
Total	25,500	7,380	3,250,000
2010:			
January–June	13,700	3,850	912,000
July–December	14,400	4,160	1,290,000
Total	28,100	8,000	2,210,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free on board mine.

TABLE 5

U.S. EXPORTS OF DIAMMONIUM PHOSPHATE[1, 2]

(Thousand metric tons and thousand dollars)

Country	2009		2010	
	Quantity	Value	Quantity	Value
Argentina	88	32,300	147	69,200
Brazil	144	35,200	151	59,800
China	348	106,000	59	16,700
Colombia	76	24,400	127	57,200
India	3,210	1,030,000	2,550	1,080,000
Japan	162	51,200	166	64,100
Mexico	208	68,600	216	88,400
Pakistan	146	45,000	113	55,100
Peru	136	40,400	59	23,700
Thailand	67	21,400	99	51,100
Other	946 [r]	365,000 [r]	402	148,000
Total	5,530	1,820,000	4,090	1,710,000

[r] Revised.

[1] Presentation of annual data is based on the top 10 quantities (gross weight) of the leading countries in 2010.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 6

U.S. EXPORTS OF MONOAMMONIUM PHOSPHATE[1, 2]

(Thousand metric tons and thousand dollars)

Country	2009		2010	
	Quantity	Value	Quantity	Value
Argentina	231	68,500	258	112,000
Australia	257	90,300	330	153,000
Brazil	495	158,000	588	255,000
Canada	601	196,000	647	263,000
Chile	46	14,000	76	28,700
China	12	3,600	26	8,020
Colombia	92	29,100	133	66,900
Ecuador	18	6,910	25	11,000
Japan	64	20,700	71	26,300
Mexico	106	35,900	96	43,900
Other	184 [r]	94,500 [r]	79	33,000
Total	2,110	717,000	2,330	1,000,000

[r] Revised.

[1] Presentation of annual data is based on the top 10 quantities (gross weight) of the leading countries in 2010.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 7
U.S. EXPORTS OF PHOSPHORIC ACID[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
Country	Quantity	Value	Quantity	Value
Brazil	35	16,400	96	42,600
Canada	29	8,400	17	4,860
India	404	96,800	456	153,000
Mexico	60	18,000	60	17,500
United Arab Emirates	(2)	48	31	10,500
Other	7	2,780 r	14	6,880
Total	535	142,000	673	235,000

[r] Revised.

[1] Excludes superphosphoric acid tonnage.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8
U.S. EXPORTS OF ELEMENTAL PHOSPHORUS[1]

	2009		2010	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Brazil	14,300	58,900	14,100	46,200
Canada	1,270	3,640	950	3,180
Mexico	517	995	2,830	5,420
Other	1,250	2,500	389	1,820
Total	17,300	66,000	18,300	56,600

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship values.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF PHOSPHATE ROCK AND PHOSPHATIC MATERIALS[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
Phosphatic materials	Quantity	Value[2]	Quantity	Value[2]
Phosphate rock:				
Unground[3]	988	83,100	1,280	117,000
Ground[3]	379	26,900	605	48,900
Total[4]	2,000	161,000	2,400	211,000
Dicalcium phosphate	6	11,200	7	9,990
Elemental phosphorus	4	15,600	7	23,500
Normal superphosphate	(5)	114	4	1,400
Triple superphosphate	38	9,340	189	66,900
Diammonium phosphate	22	9,710	190	101,000
Monoammonium phosphate	62	38,800	269	151,000
Fertilizer containing nitrates and phosphates	1	492	(5)	182
Phosphoric acid	31	30,600	31	20,600

[1] Data are rounded to no more than three significant digits.

[2] Declared cost, insurance, freight values.

[3] Some phosphate rock tonnages and values were suppressed by the U.S. Census Bureau.

[4] Includes an estimate for data not reported by U.S. Census Bureau.

[5] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10

PHOSPHATE ROCK, BASIC SLAG, AND GUANO: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

	Gross weight					P_2O_5 content				
Commodity and country[3]	2006	2007	2008	2009	2010[e]	2006	2007	2008	2009	2010[e]
Phosphate rock:										
Algeria[e]	1,510[4]	1,800[4]	1,805[4]	1,070[r]	1,800	450	536	542	305[r]	540
Australia[e]	2,750[4]	2,850[4]	2,950	2,500[r]	2,600	770	655	678	575[r]	600
Brazil, concentrate	5,932	6,185	6,343	6,000[r]	5,700	2,111	2,185	2,242	2,100[r]	2,000
Burkina Faso[e]	2	2	2	2	2	1	1	1	1	1
Canada[e]	500	700	700	670[r]	700	165	210	210	200	200
Chile:										
Apatite	12	13	21	11	15	4[e]	4[e]	7[e]	3[e]	5
Guano	--	--	3	2	2	NA	NA	NA	NA	NA
Phosphorite	2	12	17	1	1	NA	NA	NA	NA	NA
China	38,600	45,400	50,700	60,200	68,000[4]	11,600	15,100	15,200	18,000	20,400[4]
Colombia[e]	43	43	27	27[r]	30	8	8	8	8	8
Egypt, beneficiated	2,177	3,890	5,523	6,627[r]	6,000	653	1,167	1,657	2,000[r]	1,920
Finland[e]	825	825	825	650[r]	825	300	300	300	225[r]	300
India[e]	1,200	1,210	1,220	1,230	1,240	355	358	631	640	645
Indonesia[e]	1	1	1	1	1	(5)	(5)	(5)	(5)	(5)
Iran[e]	325	330	325	330	330	40	41	36	40	40
Iraq, beneficiated[e]	1	1	10	30	10	(5)	(5)	3	10	3
Israel	2,949	3,069	3,088	2,697	3,135[4]	810[e]	840[e]	850[e]	740[e]	860
Jordan	5,805	5,552	6,265	5,281	6,000	1,860	1,780	2,005	1,620	2,000
Kazakhstan[e]	845[4]	720[4]	1,226[4]	1,225[r, 4]	1,600	195	165	280	280	350
Korea, North[e]	300	300	300	300	300	95	95	95	95	95
Mexico	8	42	968	1,443	1,507[4]	2	14	291	433	452[4]
Morocco[6]	27,400	27,800	24,500	18,400[r]	25,800	8,700	8,900	7,850	6,000[r]	8,500
Nauru[e]	45	45	45	45	45	17	17	17	17	17
Pakistan	2	4[r]	4[r]	4[r]	4	(5)	1[r]	1[r]	1[r]	1
Peru[e]	38	57	38	38	791[4]	11	17	11	11	237
Philippines	2	2	2	2[r]	2	1	1	1	1[r]	1
Russia[e]	11,000	11,400	10,400	9,500[r]	11,000	4,000	4,200	3,800	3,500[r]	4,000
Senegal	584	691	645	950[r, e]	950	180	234	180	320[r, e]	320
South Africa	2,629	2,556	2,287	2,237	2,494[4]	966[r]	986[r]	959[r]	858[r]	935[4]
Sri Lanka[e]	42[4]	40[4]	42[r, 4]	42[r, 4]	42	15	15	15	15	15
Syria	3,664	3,678	3,221	2,466	3,000	1,130[e]	1,140[e]	993	1,030[e]	930
Tanzania	3	8	29[r]	1[r]	1	1	3	9	(5)[r]	(5)
Thailand	1	4	4	3[r]	3	(5)[e]	1[e]	1[e]	1[r, e]	1
Togo[e]	1,650[4]	750[4]	842[4]	726[r, 4]	850	590	270	303	260[r]	300
Tunisia, washed[e]	7,801[4]	8,005[4]	7,623[4]	7,398[4]	7,600	2,300	2,400	2,300	2,200	2,200
United States	30,100	29,700	30,200	26,400	25,800[4]	8,680	8,480	8,590	7,640	7,400[4]
Uzbekistan[e]	600	600	600	600	800	140	140	140	140	200
Venezuela[e]	400[4]	400	400	400	400	115	115	115[r]	115[r]	115
Vietnam	1,232	1,523	2,101[r]	1,896[r]	2,000	370[r]	460[r]	630[r]	570[r]	600
Zimbabwe, concentrate[e]	66[4]	30	30	30	30	21	10	10	10	10
Total	151,000	160,000	165,000	161,000[r]	181,000	46,700[r]	50,800[r]	51,000[r]	50,000[r]	56,200
Basic (Thomas converter) slag:[e]										
Egypt	--[r]	--[r]	--[r]	--[r]	--	--[r]	--[r]	--[r]	--[r]	--
France	50	50	50	50	50	8	8	8	8	8

See footnotes at end of table.

TABLE 10—Continued

PHOSPHATE ROCK, BASIC SLAG, AND GUANO: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Commodity and country[3]	Gross weight					P_2O_5 content				
	2006	2007	2008	2009	2010[e]	2006	2007	2008	2009	2010[e]
Basic (Thomas converter) slag—Continued:[e]										
Luxembourg	475	475	475	475	475	70	70	70	70	70
Total	525 r	525 r	525 r	525 r	525	78 r	78 r	78 r	78 r	78

[e]Estimated. [r]Revised. NA Not available. -- Zero.

[1]World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Table includes data available through May 13, 2011. Figures are from official country sources where available.

[3]In addition to the commodities listed, phosphate rock may be produced in Nigeria, but information is inadequate to estimate output.

[4]Reported figure.

[5]Less than ½ unit.

[6]Includes production from Western Sahara.

PLATINUM-GROUP METALS

By Patricia J. Loferski

Domestic survey data and tables were prepared by Pamela A. Wiser, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, Stillwater Mining Co. (SMC) (Billings, MT) was the only domestic mine producer of platinum-group metals (PGMs) from its Stillwater Mine near Nye, MT, and its East Boulder Mine south of Big Timber, MT. OJSC MMC Norilsk Nickel (Moscow, Russia), which had been the majority owner of SMC since 2003, sold its entire stake in SMC to a number of independent investors. SMC produced 15,100 kilograms (kg) of platinum and palladium in 2010, 8% less than the 16,500 kg that was produced in 2009 (Stillwater Mining Co., 2011a, p. 52–53). Defense National Stockpile Center reported no PGM sales in 2010; 18 kg of iridium and 261 kg of platinum remained in the stockpile. Palladium stocks were exhausted in 2004.

In 2010, the automobile industry continued to be a major consumer of PGMs. Autocatalysts accounted for approximately 77% of rhodium consumption, 57% of palladium consumption, and 46% of platinum consumption on a global basis. Jewelry was the second leading use of platinum in 2010, at 31% of global consumption, down from 41% in 2009. The jewelry use declined because of the rise in platinum price in 2010 compared with that of 2009 (Butler, 2011, p. 28–30).

Legislation and Government Programs

In December, the American Eagle Palladium Bullion Coin Act of 2010 was signed into law (Public Law 111–303), authorizing the U.S. Treasury to produce palladium bullion coins for sale to investors. Production of the coins was dependent upon the outcome of an independent study to determine if adequate demand existed for the coins to be minted and issued at no cost to the taxpayer. The coins were planned to be 1 troy ounce with a face value of $25 (Johnson Matthey, 2010).

Production

Primary.—During 2010, the Stillwater Mine produced 8,420 kg of palladium and 2,520 kg of platinum, 10% and 12% less, respectively, relative to production in 2009. PGM production from the East Boulder Mine was 4,150 kg (3,220 kg of palladium and 930 kg of platinum), which was a 2% and 3% decrease, respectively, in palladium and platinum production compared with that of 2009. Total palladium and platinum production for SMC decreased by 8% and 10%, respectively, compared with production in 2009. Production of rhodium in 2010 was 62 kg, which was one-half the amount of production in 2009 (Stillwater Mining Co., 2011a, p. 53). The company milled 1.10 million metric tons (Mt) of ore from the mines, slightly more than that in 2009. Decreased production at the Stillwater Mine was attributed to lower grade ore in the offshaft area as well as infrastructure rehabilitation and increased ground support requirements that slowed mining in some areas for several weeks. SMC increased its recycling business; consolidated the business in the metallurgical complex in Columbus, MT; and created a new corporate subsidiary, Stillwater Metals Co., for its recycling operations. Construction was completed on a new x-ray assay facility at the recycling complex, which increased SMC's receiving and sampling capacity fourfold. About 40% of the recycled material was from material purchased by SMC, and the remainder was toll processed for others for a fee. SMC moved its headquarters office to Billings, MT, from Columbus, MT, in 2010 (Stillwater Mining Co., 2011b).

Mining productivity in terms of mill feed was similar to that of 2009, at 2,130 metric tons per day (t/d) at the Stillwater Mine and 1,100 t/d at the East Boulder Mine. In 2011, SMC planned to resume mining on the east side of the Stillwater Mine, which has higher ore grades than the offshaft area (Stillwater Mining Co., 2011a, p. 10).

SMC's sales contract with Ford Motor Co. (Dearborn, MI) expired at yearend. The company entered into new contracts with Ford, General Motors Corp. (Detroit, MI), and BASF Corp. (Florham Park, NJ). The new sales contracts were based on prevailing market prices and were for fixed ounces of PGMs to be delivered on a monthly basis (Stillwater Mining Co., 2011a, p. 10).

SMC planned to proceed with two mine expansion projects in the Stillwater Complex—the Graham Creek project, immediately to the west of the East Boulder Mine, and the Blitz project, immediately to the east of the Stillwater Mine. Both projects were within the boundaries of existing mining permits. The Graham Creek project would extend the East Boulder Mine about 2,500 meters (m) further west, and production from the project was expected to be 6 Mt of ore grading at 13 grams per metric ton (g/t) PGMs. The Blitz project would extend about 4,100 m to the east of the Stillwater Mine via two footwall laterals and was expected to yield as much as 9.5 Mt of ore grading at 22 g/t PGMs. Development and resource evaluation of both projects was expected to take place during the next 5 to 6 years (Stillwater Mining Co., 2011a, p. 5–6). SMC also completed its acquisition of Marathon PGM Corp.'s (Toronto, Ontario, Canada) Marathon PGM-copper project in Ontario. The Marathon project was scheduled to come into production during the next 3 years and produce 6,220 kilograms per year (kg/yr) of platinum and palladium for as many as 12 years. SMC also announced that it entered into a definitive agreement to acquire Benton Resources Corp.'s (Thunder Bay, Ontario, Canada) Bermuda Property. The 7,300-hectare Bermuda Property was located along the eastern and northern margins of the Coldwell Complex near Marathon, Ontario, and was adjacent to SMC's recently purchased Marathon PGM-copper project. Through the agreement, SMC would also acquire Benton's royalty position on the Marathon PGM-copper deposit (Stillwater Mining Co., 2011a, p. 7–8).

SMC announced the exit of its majority stockholder, Norimet Ltd. (London, United Kingdom), a wholly owned subsidiary of OJSC MMC Norilsk Nickel (Moscow, Russia). Norimet sold its entire 51.3% stake in SMC in two separate secondary offerings (Stillwater Mining Co., 2011a, p. 9).

At yearend 2010, SMC reported proven and probable reserves of 41.0 Mt with an average grade of 15 g/t containing about 620,000 kg of palladium and platinum, with an in-situ palladium-to-platinum ratio of about 3.57 to 1. Average mill head grades ranged from 16 g/t at the Stillwater Mine to 12 g/t at the East Boulder Mine. SMC's proven and probable reserves of PGMs are contained in the J-M Reef, an ore body within the layered mafic and ultramafic igneous rocks of the Stillwater Complex. SMC planned to produce 15,600 kg of PGMs in 2011 (Stillwater Mining Co., 2011a, p. 8, 10, 14).

In 2010, PGM exploration continued at several locations in the United States. The most advanced projects were in the Duluth Complex of Minnesota. PolyMet Mining Corp.'s (Hoyt Lakes, MN) primary focus continued to be completion of the environmental review and permitting process to enable construction and operation of the NorthMet Mine. U.S. Army Corps of Engineers and the U.S. Forest Service, colead Federal agencies responsible for the environmental impact statement (EIS) reviewing PolyMet's copper-nickel-precious metals project, published a notice of intent to complete a supplemental draft EIS. The colead Federal agencies were working with the Minnesota Department of Natural Resources, the State lead agency, the U.S. Environmental Protection Agency, and other cooperating agencies involved in the EIS process. The supplemental draft EIS included a proposed land exchange between the U.S. Forest Service Superior National Forest and PolyMet. The land exchange was expected to improve intermingled and inefficient ownership patterns and eliminate conflicts if minerals development was to expand in the future. The lands that would be received by the Superior National Forest consisted of forest and wetland habitat as well as lake frontage. The supplemental draft EIS was expected in the summer of 2011, with the final EIS anticipated 6 to 9 months later (PolyMet Mining Corp., 2010).

Duluth Metals Ltd. (Toronto, Ontario, Canada) entered into a joint venture with Antofagasta plc (London, United Kingdom) to advance the copper-nickel-PGM Nokomis Project in the Duluth Complex, MN. Prefeasibility and bankable feasibility studies on the Nokomis deposit were expected to be completed by 2013 (Duluth Metals Ltd., 2010b). Duluth Metals planned to complete exploratory and development drilling, mine planning, metallurgical testing, prefeasibility and feasibility studies, as well as continued environmental data collection and analysis on Nokomis by March 2012 (Duluth Metals Ltd., 2010c). Duluth Metals also planned to begin an exploration program for copper-nickel-PGM deposits on its properties in the Duluth Complex which fall outside the areas of the Nokomis deposit; these were not included in the Antofagasta joint venture. Duluth Metals planned a drilling program on the new properties, on which historical drilling activity was very limited. The company thought that mineralization on these properties was similar to that of the Nokomis deposit. Duluth Metals had previously concentrated on the discovery and advancement of the Nokomis deposit (Duluth Metals Ltd., 2010d).

Duluth Metals entered into an agreement with Franconia Minerals Corp. (Spokane Valley, WA) in which Duluth would acquire 100% of the outstanding common shares of Franconia. Franconia's main asset was a 70% interest in the Birch Lake, Maturi, and Spruce Road nickel-copper-PGM deposits in the Duluth Complex in northeastern Minnesota, through the Birch Lake joint venture. The Franconia assets, which were near Duluth Metals' Nokomis deposit, were planned to be rolled into Twin Metals Minnesota LLC, the Duluth Metals (60%) and Antofagasta plc (40%) joint venture. The transaction was subject to approval by Franconia shareholders at a special meeting expected to take place in February 2011 (Duluth Metals Ltd., 2010a).

In Alaska, Pure Nickel, Inc. (Toronto, Ontario, Canada) continued exploration of the nickel-copper-cobalt-PGM MAN property 265 kilometers (km) south-southeast of Fairbanks. Pure Nickel completed 6,700 meters of drilling in 2010, which was funded by its partner, ITOCHU Corp. (Tokyo, Japan). A new company was created, called MAN Alaska LLC, to hold the MAN property claims. MAN Alaska LLC was jointly owned by Nevada Star Resource Corp. (Bellevue, WA) (70%), a wholly owned subsidiary of Pure Nickel, and ITC Mineral Resources Development Inc. (Tokyo, Japan) (30%), a wholly owned subsidiary of ITOCHU (Pure Nickel, Inc., 2011, p. 3).

Secondary.—In 2010, PGMs were recycled from three main sources—autocatalysts, electronics, and jewelry. The global recovery of platinum from recycling of autocatalysts increased by 31% in 2010 compared with that of 2009, reaching 33,700 kg. In North America, recovery of platinum from catalytic converters was an estimated 18,000 kg of platinum, which was a 36% increase compared with that in 2009, and represented roughly 53% of global autocatalyst recycled material. Recovery of platinum from catalytic converters increased by 29% and 20% in Europe and Japan, respectively, and was unchanged in China compared with 2009 quantities. In the rest of the world, recycling of autocatalysts produced about 11% more platinum in 2010 compared with that of 2009. Globally, recycling of autocatalysts increased partly as a result of car scrappage incentive programs put in place in 2009. Catalysts collected from scrapped automobiles were processed in 2010. About 311 kg of platinum was recovered from electronics recycling in 2010, which was the same amount recovered in 2009. About 23,200 kg of platinum was recovered from the jewelry industry globally, an increase of 32% compared with that of 2009 (Butler, 2011, p. 24).

About 41,200 kg of palladium was recovered from autocatalysts globally in 2010, an increase of 37% compared with that of 2009. Roughly 60% of global recycled palladium came from North America. Palladium recovery from autocatalysts in North America increased by 46% to 24,600 kg, and that in Europe increased by 20% to 10,400 kg relative to that in 2009. Palladium recovery from autocatalysts in Japan increased by 50% and that in China increased by 43% compared with levels in 2009. Recycling of palladium from electronics totaled 113,700 kg in 2010, an increase of 11% compared with that of 2009. Recycling of palladium from the jewelry industry totaled about 2,490 kg in 2010, which was about 14% less than that of 2009. In 2010, global recovery of rhodium from autocatalysts increased by 26% to 7,300 kg (Butler, 2011, p. 24).

SMC's recycling program recovered 12,400 kg of PGMs in 2010, an increase of 59% as compared with that of 2009. Recycled material sales were $168.6 million in 2010, which was more than double the 2009 sales value (Stillwater Mining Co., 2011a, p. 50).

Consumption

In 2010, global platinum sales totaled 245,000 kg, a 16% increase compared with sales in 2009. About 46% of the total was consumed by the autocatalyst industry, about 31% by the jewelry industry, and about 8% was used as investment. The remainder was used in other industries including chemical, electrical, glassmaking, and medical and biomedical. Platinum use in the autocatalyst sector increased by 43% as a result of an increase in light-duty vehicle production, which in turn was the result of the effects of the global economic downturn (Butler, 2011, p. 4).

Global palladium sales were 299,000 kg in 2010, about 23% more than those in 2009. About 57% of the total was used by the autocatalyst industry, about 15% by the electronics industry, and about 11% as investment. The remaining amount was used in industries such as chemical, dental, jewelry, and others (Butler, 2011, p. 36).

In 2010, U.S. apparent consumption of refined platinum was estimated to be about 139,000 kg, a 19% decrease from the apparent consumption of 171,000 kg in 2009. Apparent domestic palladium consumption was estimated to be about 44,300 kg, a 15% decrease from 52,100 kg in 2009.

Palladium.—Palladium use in autocatalysts increased by 35% globally to 170,000 kg in 2010 compared with 2009 consumption. Demand in Europe increased by 33% to 41,000 kg. The increase was partly a result of auto scrappage plans which had the effect of increased sales for small gasoline-powered, rather than diesel, vehicles. Additionally, European automakers continued to increase substitution of palladium for platinum in diesel catalytic converters, with most diesel catalysts containing about 25% palladium. European automakers increased exports in 2010, with the majority going to gasoline markets such as China.

Consumption in the North American autocatalyst sector increased to 42,300 kg, a 33% increase relative to that of 2009 owing to increased auto production and sales. Palladium consumption in the Japanese autocatalyst industry was 25,300 kg, a 38% increase compared with that of 2009. Palladium consumption for autocatalysts in China increased to 30,300 kg, a 42% increase relative to that of 2009. Palladium consumption for autocatalysts in the rest of the world increased by 28% to 30,300 kg relative to that of 2009 (Butler, 2011, p. 36–39).

On a global basis, palladium consumption by the jewelry industry was 19,300 kg, a 20% decrease in 2010 compared with that of 2009. The decrease was largely a result of the 32% drop in demand from China, to 11,800 kg of palladium, partly because of higher prices as well as sufficient levels of stock. Nevertheless, China was again by far the leading user of palladium for jewelry, with 61% of world consumption in that sector. The much smaller markets in Europe and North America showed increases in palladium use in jewelry in 2010. Consumption in Europe was 2,180 kg of palladium, a 40% increase relative to that of 2009, and consumption in North America was 2,020 kg, an 8% increase compared with that of 2009. Consumption in Japan was 2,330 kg of palladium, a 6% decrease relative to that of 2009 (Butler, 2011, p. 39–40).

World palladium consumption in dental alloys was 18,000 kg in 2010, which was about 9% less than consumption in 2009. Japan and North America each consumed about 43% of the global consumption in that sector. The chemical industry consumed 12,300 kg of palladium in 2010, a 22% increase from that in 2009. In the chemical industry, palladium was used mainly as a catalyst in manufacturing bulk chemicals, including purified hydrogen peroxide, nitric acid, purified terephthalic acid, and vinyl acetate monomer, which was a component of many resins and plastics. The global increase in palladium demand was the result of increased consumer demand for end products that use these various chemicals in their manufacturing. Consumption of palladium by the electronics industry was 43,900 kg in 2010, which was a 3% increase compared with that of 2009, a result of increased consumer purchasing of electronic products. Demand increased both for resistors and for multilayer ceramic capacitors (MLCCs), which have widespread use in electronic circuitry. Use of palladium in other applications increased by 21% in 2010 compared with that of 2009. Such uses included stationary-source emission control and petroleum refining catalysts. Purchases of palladium for investment increased to 33,700 kg, 74% higher than those of 2009. Holdings in exchange-traded funds (ETFs) were 68,400 kg at yearend 2010, an increase of 84% compared with holdings at yearend 2009 (Butler, 2011, p. 42).

Platinum.—Global use of platinum in the autocatalyst sector increased by 43% to 97,200 kg in 2010 compared with that in 2009. Consumption in Europe was about 45,600 kg of platinum in 2010, which was 51% more than that of 2009, and accounted for about 47% of the global total. The market share of light-duty diesel vehicles in Europe increased to about 48% in 2010 from 46% in 2009. Consumption in the autocatalyst sector for North America was 15,100 kg, an increase of 31% in 2010 relative to that of 2009 owing to the increase in automobile purchases in response to the global financial upswing. In Japan, platinum demand in the autocatalyst sector was 17,000 kg, about 38% more than that of 2009. In China, demand for platinum in the autocatalyst sector increased by 44% to 16,300 kg. Consumption of platinum for autocatalysts increased by 44% in other areas of the world in 2010 relative to that of 2009 (Butler, 2011, p. 25–28).

In 2010, global consumption of platinum in the jewelry industry decreased as a result of higher metal prices. Consumption in this sector was 75,100 kg of platinum, a 14% decrease compared with that of 2009. Consumption in North America increased by 30% relative to that of 2009, partly in response to a narrowing of the price difference between gold and platinum in 2010. Consumption in Europe and Japan decreased by 5% and 3%, respectively. Consumption in China decreased by 21% during the same time period. China remained, by far, the leading consumer of platinum in this sector at 51,300 kg, accounting for 74% of global consumption of platinum for jewelry (Butler, 2011, p. 28–30).

Global use of platinum in the chemical sector was 13,800 kg in 2010, which was an increase of 53% compared with that of 2009. The increase was a result of increased capacity utilization in chemical plants in response to a stronger global economy. In contrast to other industrial sectors, purchases of platinum by the petroleum refining industry decreased by 19% to 5,230 kg in 2010, a result of decreased capacity utilization in response to lingering effects of the economic downturn of 2009. The global consumption of platinum in electrical applications increased by 16%, to 6,840 kg in 2010, compared with that of 2009, owing to strengthening consumer demand (Butler, 2011, p. 31–32).

Because of its high melting point and resistance to corrosion, platinum equipment is used in the glassmaking industry. Platinum consumed in the glass industry skyrocketed to 10,700 kg in 2010 from 311 kg in 2009. The dramatic increase was a result of several factors, including increased consumer demand for flat-panel displays that use platinum in the production of liquid crystal displays, and increased industrial demand for fiberglass in the building industry. Consumption in the medical and biomedical sector was 7,930 kg, which was slightly higher than that in 2009. Consumption in other end uses increased to 7,900 kg, a 34% increase relative to that of 2009. These categories included use in automotive sensors, coating of aircraft turbine blades, and spark plugs. Investment demand for platinum decreased slightly to 20,200 kg. By yearend 2010, platinum holdings in ETFs increased to 37,300 kg (Butler, 2011, p. 25–33).

In 2010, the U.S. Mint did not sell any platinum American Eagle Bullion coins (U.S. Mint, 2011).

Other PGMs.—Global rhodium consumption in 2010 was 27,200 kg, a 22% increase compared with that of 2009. A majority of rhodium use, 77% in 2010, was in the production of autocatalysts. In 2010, rhodium use in autocatalysts increased to 22,500 kg, which was 17% more than that of 2009. Demand for rhodium in the autocatalyst sector increased in China, Japan, and North America as a result of increasing vehicle production. In contrast, rhodium demand decreased in Europe because of thrifting by autocatalyst manufacturers. Use of rhodium in the glass manufacturing sector increased sharply to 1,770 kg, a 200% rise in 2010 compared with that in 2009. The increase was owing to increased demand for fiberglass and flat-panel glass. Consumption of rhodium in the chemical sector increased by 26% to 2,110 kg in 2010 owing to increased capacity utilization rates in oxoalcohol manufacturing plants in Asia. Demand from the electrical sector increased by 33% in 2010, to 124 kg, whereas demand in other applications was down by 5% from that of 2009, at 622 kg (Butler, 2011, p. 44).

Global consumption of ruthenium increased by 79% to 32,000 kg in 2010 relative to that in 2009. The consumption of ruthenium in electrical applications increased to 23,400 kg from 10,500 kg in 2009, mainly a result of increased consumption of primary ruthenium in the hard disk industry. Electrochemical demand was 4,100 kg, a 39% increase compared with that of 2009. Its use in the chemical sector rose to 3,110 kg, a 12% increase compared with that in 2009. Consumption of ruthenium in other applications decreased to 1,340 kg, 20% less than that in 2009 (Butler, 2011, p. 45).

Global consumption of iridium increased strongly to 10,400 kg in 2010 from 2,520 kg in 2009. The largest increase of iridium use was in the electrical sector at 6,030 kg in 2010 compared with 218 kg in 2009. Iridium crucibles are used in the electronics industry to grow high-purity single crystals for use in various applications. Single crystal sapphire was used in the production of back-lit light-emitting diode televisions. Increased demand for these televisions led to increased demand for iridium crucibles (Butler, 2011, p. 45).

Prices

In 2010, the Engelhard annual average price of palladium doubled and that of platinum increased by 34% compared with the 2009 annual average prices. As for the other PGMs, the 2010 iridium annual price increased by 53%, and rhodium and ruthenium annual prices increased by 55% and 104%, respectively, compared with the 2009 prices (table 1).

Iridium.—In the beginning of January, the price of iridium was $420 per troy ounce. The price increased steadily through May, when it reached $715 per troy ounce. The price held steady until late October, when it increased to $745 per troy ounce, and ended the year at $780 per troy ounce, which was a 30-year high. The large price increase was the result of increased purchases of iridium by the electrochemical and electronics sectors.

Palladium.—Palladium prices began the year at $422 per troy ounce, increased to $573 per troy ounce in April, and decreased to $433 per troy ounce in late May. For the rest of the year, the price trend was upwards in response to increased investor interest and increased demand from the automobile sector. The palladium price ended the year at $800 per troy ounce, which was its highest level in 10 years.

Platinum.—Although the platinum price was volatile throughout the year, the annual average price reached an alltime high. Platinum began the year at $1,510 per troy ounce, increased to $1,750 per troy ounce in late April, and decreased to $1,495 per troy ounce in late May. The price remained below $1,600 per troy ounce until mid-September, when it increased steadily through the beginning of November, when it reached the year's high at $1,790 per troy ounce. The price ended the year at $1,754 per troy ounce. The price increase toward the yearend was driven by strong investment demand.

Rhodium.—The rhodium price began the year at $2,625 per troy ounce, increased to $2,975 per troy ounce in mid-April, then decreased steadily for the next 5 months, dropping to $2,120 per troy ounce in mid-August. The price increased to $2,350 per troy ounce in late September and ended the year at $2,425 per troy ounce. The midyear price decline was owing to lack of buying interest. The increase toward yearend was in response to news of increased car sales in China.

Ruthenium.—The ruthenium price increased strongly during the first half of the year and then decreased strongly in the second half of the year. The price began the year at $170 per troy ounce, rose to $245 per troy ounce in early May, where it remained until late June, and then decreased steadily for the next 6 months to end the year at $180 per troy ounce. The ruthenium price increased owing to purchasing by the electronics sector and decreased owing to decreased industrial demand.

Foreign Trade

In 2010, the U.S. net import reliance as a percentage of apparent consumption was estimated to be 74% for refined palladium and 98% for refined platinum. Imports of refined palladium in 2010 increased slightly to 70,700 kg from 69,700 kg in 2009, with three countries accounting for about 72% of refined palladium imports in 2010—South Africa (33%), Russia (26%), and the United Kingdom (13%). Imports of platinum, including waste, scrap, and coins, decreased by 17% in 2010 to 152,000 kg, from 183,000 kg in 2009. Excluding waste and scrap, three countries accounted for 73% of imports of platinum in 2010—South Africa (50%), the United Kingdom (15%), and Germany (9%). Refined imports of other PGM decreased by 10% in 2010 compared with those of 2009. Imports of iridium increased by 132% to 3,530 kg; those of rhodium and osmium increased by 15% and 12%, respectively, and those of ruthenium decreased by 33% compared with those of 2009. Three countries accounted for 89% of the imports of other PGM in 2010—South Africa (66%), the United Kingdom (12%), and Germany (11%) (tables 2, 3).

About 38,100 kg of palladium was exported in 2010, an increase of 26% relative to palladium exports in 2009. Exports of platinum, including waste and scrap, increased by 17% to 55,100 kg, and exports of rhodium increased by 90% compared with exports in 2009. Exports of iridium, osmium, and ruthenium decreased by 8% during the same time period (table 4).

World Review

In 2010, world mine production of PGMs increased by 4% to 467,000 kg compared with 449,000 kg in 2009 (table 5). South Africa, the world's leading producer of PGMs, accounted for 62% of total mine production in 2010; Russia accounted for 26%, Zimbabwe accounted for 4%, and Canada and the United States each accounted for 3%. In 2010, platinum production from South Africa totaled 148,000 kg, which represented 77% of world platinum production and was a 5% increase relative to South African production in 2009. Global output of palladium increased to 202,000 kg, with Russia and South Africa accounting for 42% and 41%, respectively, of the total. The United States accounted for 6% of world palladium production. World production of other PGMs (iridium, osmium, ruthenium, and rhodium) in 2010 increased by 3% as compared with that of 2009. South Africa was the dominant producer, accounting for 78% of the total global production of other PGMs.

Botswana.—In 2010, Norilsk Nickel produced 3,330 kg of palladium and 560 kg of platinum as byproducts from its nickel operations at the Tati Mine. These quantities represented increases of 7% and 6%, respectively, in palladium and platinum production compared with that in 2009 (OJSC MMC Norilsk Nickel, 2011, p. 4).

Canada.—North American Palladium Ltd. (Toronto) produced 2,960 kg of palladium and 156 kg of platinum from its Lac des Isles Mine. The mine was reopened in April 2010 after having been placed on care-and-maintenance status in October 2008 in response to low metal prices (North American Palladium Ltd., 2011).

Xstrata plc (Zug, Switzerland) continued to produce PGM as byproducts from nickel mining operations at Sudbury, although production figures were not released. Xstrata's Nickel Rim South Mine probably produced more than 1,900 kg of platinum and a similar amount of palladium (Butler, 2011, p. 21). Vale Inco Ltd. (Toronto) produced 1,870 kg of palladium and 1,090 kg of platinum as byproducts of its nickel operations at Sudbury. These data reflect production decreases for palladium and platinum of 61% and 66%, respectively, relative to production in 2009. Production was severely affected by a year-long strike which ended in July 2010 (Butler, 2011, p. 21).

Russia.—In 2010, Russia accounted for 42% of global mine production of palladium, 13% of platinum production, and 16% of other PGMs. Norilsk Nickel produced 84,700 kg of palladium and 20,600 kg of platinum in 2010, a slight increase for palladium and a 4% increase for platinum compared with 2009 production (OJSC MMC Norilsk Nickel, 2011). Russia's alluvial production was about 4,510 kg of platinum, which was a 3% decrease compared with 2009 production (Butler, 2011, p. 20–21).

South Africa.— In 2010, South African production of platinum and palladium increased by 5% and 9%, respectively, compared with 2009 production. The world's leading PGM producer, Anglo American Platinum Ltd. (Johannesburg), produced 79,900 kg of platinum and 45,100 kg of palladium in 2010, increases of 5% for platinum and 6% for palladium relative to production in 2009. Rhodium production was 10,200 kg in 2010, a decrease of 6% relative to that of 2009. The older operations on the western limb of the Bushveld Complex generally had lower output in 2010 relative to that of 2009, whereas production at the newer operations was generally higher. Output from the Khuseleka and Siphumelele Mines (formerly part of the Rustenburg section) was 4,000 kg and 2,900 kg of platinum and palladium, respectively, which were decreases of 17% and 14%, respectively, relative to that of 2009. Platinum production from the Mototolo Mine, a joint venture with Xstrata, was 3,360 kg, slightly lower than 2009 production. The Kroondal and Marikana Mines, operated as pool-and-share agreements with Aquarius Platinum Ltd. (Perth, Australia), produced 7,911 kg and 1,640 kg of platinum, respectively, which were increases of 9% and 32% respectively, relative to that of 2009. Operations at Mogalakwena continued to ramp up, and 2010 production was 8,100 kg, an increase of 10% relative to that of 2009. At Modikwa, a joint venture with African Rainbow Minerals Ltd. (ARM) (Sandton), platinum production was 4,030 kg, which was a 4% decrease relative to that of 2009. At the Bafokeng-Rasimone Platinum Mine (BRPM) joint venture with Royal Bafokeng Platinum (Johannesburg), refined platinum production was 5,740 kg, a 7% increase relative to 2009 production. Anglo expected to produce 80,900 kg of platinum in 2011 (Anglo American Platinum Ltd., 2011, p. 49–83).

Impala Platinum Holdings Ltd.'s (Johannesburg) refined production of platinum in 2010 was 33,700 kg, a 5% decrease compared with that of 2009. Output at the Impala Mine was

27,100 kg of platinum, an 8% decrease relative to that of 2009. The decrease was the result of safety stoppages following the deaths of 15 workers and the resulting revisions to mining methods. Production at Impala also decreased owing to a 2-week stoppage that took place as a result of a workers' strike. Marula Mine had a difficult year, and ramp up was slow. Production at Marula decreased to 2,180 kg of platinum, a 5% decrease relative to that of 2009. Production at the Two Rivers Mine included 4,400 kg of platinum in concentrate, which was a 19% increase compared with that of 2009 as a result of continued progress toward ramp up to full capacity. Impala expected to produce 4,670 kg/yr of platinum by 2013 from Two Rivers (Impala Platinum Holdings Ltd., 2011, p. 73–95).

In 2010, Northam Platinum Ltd. (Johannesburg) reported production from its Zondereinde Mine of nearly 10,000 kg of PGMs in concentrate, a 6% increase compared with production in 2009 (Northam Platinum Ltd., 2011, p. 5).

Lonmin plc (London) reported production for 2010 of 21,600 kg of platinum and 10,100 kg of palladium, increases of 5% each, relative to 2009 production. Rhodium production was 3,000 kg, a 6% increase relative to that of 2009. Ruthenium and iridium production were 4,700 kg and 1,000 kg, respectively, increases of 8% and 7%, respectively, relative to production in 2009. Production increased owing to an increase in quantity mined, improved grades, and improved recoveries in the concentrators (Lonmin plc, 2011, p. 4, 146).

Aquarius Platinum Ltd. (Bedford) resumed production at the Everest Mine in 2010 after completing repairs following subsidence of the mined-out portion of the mine in 2009. Aquarius' attributed production from Everest was 1,680 kg of PGM. Production from Platinum Mile was 205 kg of PGM, a decrease of 39% relative to that of 2009 owing to a decline in the amount of tailings material. The Blue Ridge Mine produced 523 kg of PGM, which was a slight increase compared with 2009 production. The Blue Ridge Mine was closed temporarily in September 2010 for redevelopment and was expected to reopen in July 2011. Aquarius had two pool-and-share agreements with Anglo Platinum, at the Kroondal and Marikana Mines. Aquarius' attributed production from the Kroondal Mine was 6,870 kg of PGM, an 8% increase relative to that of 2009. Production from the Marikana Mine was 1,990 kg of PGM, which was a 12% decrease relative to that of 2009. Production from the Chromite Tailings Retreatment Plant, a joint-venture project between Aquarius (50%), GB Mining and Exploration Ltd. (Johannesburg) (25%), and Sylvania South Africa Ltd. (West Perth) (25%), was 85 kg of PGM in 2010, compared with production of 110 kg of PGM in 2009, a decrease of 23% (Aquarius Platinum Ltd., 2011, p. 17–19).

ARM platinum division had several joint ventures in South Africa—Modikwa Platinum Mine, 50% jointly owned with Anglo Platinum; Nkomati Nickel Mine, 50% with Norilsk Nickel; and Two Rivers Platinum Mine, a project in which ARM held 55% and Implats 45%. Production from Modikwa was 4,090 kg of PGM, and from Nkomati, production was 1,600 kg of PGM. Modikwa production decreased by about 3% relative to that of 2009, whereas Nkomati production nearly doubled as a result of a large-scale expansion program. Two Rivers produced 4,380 kg of PGM during 2010, which was a 19% increase relative to that of 2009 (African Rainbow Minerals Ltd., 2011, p. 38–40).

Eastern Platinum Ltd.'s (Vancouver, British Columbia, Canada) Crocodile River Mine produced 4,100 kg of PGMs in concentrate, a slight increase from that in 2009 (Eastern Platinum Ltd., 2011, p. 3).

Platmin Ltd.'s (Centurion) Pilanesburg Mine, which was still in the build-up stage, produced 1,870 kg of PGM in concentrate during its first full year of production (Platmin Ltd., 2011, p. 37).

Platinum Australia Ltd.'s Smokey Hills Mine produced about 964 kg of PGM in concentrate, which was an increase of 11% relative to that of 2009 but far less than had been anticipated. Platinum Australia faced a difficult year owing to performance issues with the mining contractor and the discovery of a previously undetected pothole in the proposed underground mining area. Potholes are geologic structures which result in displaced ore horizons (Platinum Australia Ltd., 2011, p. 2).

Zimbabwe.—In 2010, the Mimosa Mine, a joint venture between Aquarius Platinum and Impala, produced 6,260 kg of platinum, which was 7% more than that in 2009. Mimosa was operating at full capacity, and no expansions were planned for the next 5 years (Butler, 2011, p. 22). Production from Impala's Zimplats Mine was 5,490 kg of PGMs, which was 81% more than that in 2009. The phase I expansion project at Zimplats was near its full production capacity, and 4.2 Mt of ore was milled in 2010. The second phase of expansion at Zimplats was underway, including a third underground mine and a second concentrator. The phase 2 expansion was expected to be completed in 2014 and to achieve full production of 8,400 kg/yr of platinum (Impala Platinum Holdings, Ltd., 2011, p. 13, 64–73).

Anglo American Platinum's Unki Mine, near Gweru, continued development in 2010, and 392,000 metric tons of ore were mined. Anglo planned to refine as much as 933 kg of platinum during 2011 (Butler, 2011, p. 22).

Outlook

The progress of the global economic recovery is expected to be the main driver of demand for PGMs owing to their use as industrial metals. The primary end use for palladium, platinum, and rhodium is for catalytic converters in the automotive industry; therefore, the outlook for that industry will have the greatest impact on the consumption and prices of these PGMs. Economic growth remains weak in most countries, but consumer confidence is returning, and industrial output is increasing. Global automobile production is likely to increase; therefore, an overall increase in demand for PGM in that sector is expected. Manufacturers continue to switch to palladium-based catalytic converters and to increase palladium loadings on diesel light-duty vehicles because of the price difference between platinum and palladium. Thus, the increase in automobile demand, particularly in emerging markets such as China, will likely affect palladium demand in particular. In the electronics sector, palladium demand is likely to increase as the global economy recovers because of increasing demand for consumer electronics in which palladium is used in MLCCs, as well as increased palladium loadings in the MLCCs. In the glass sector, demand for platinum could decrease owing to an expected slowdown in new fiberglass production capacity installation. In the chemical sector, demand palladium is expected to rise because of an increase in construction of manufacturing facilities. The demand for platinum in the jewelry sector was expected to be about the same as that of 2009, whereas palladium jewelry demand is likely to be lower. The consumption of rhodium is expected to increase as a result of higher vehicle demand in many areas of the world. Ruthenium demand is expected to increase as a result of increased demand from the electrical and electrochemical sectors. Iridium demand is likely to decrease as a result of stock building of crucibles used for the growth of metal oxide single crystals.

On the supply side, platinum production from South Africa is expected to increase as a result of ramp up from new operations and additional output from reopened shafts that had been closed owing to low metal prices. Supply from Zimbabwe is expected to increase because of new mining projects, but this may be dependent on the political situation. Recycling of platinum and palladium is expected to increase, particularly in the automotive catalyst recycling sector.

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TABLE 1

SALIENT PLATINUM-GROUP METALS STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Mine production:						
Palladium, Pd content:[2]						
Quantity	kilograms	14,400	12,800	11,900	12,700	11,600
Value	thousands	$150,000	$148,000	$136,000	$108,000	$199,000
Platinum, Pt content:[2]						
Quantity	kilograms	4,290	3,860	3,580	3,830	3,450
Value	thousands	$158,000	$162,000	$182,000	$149,000	$179,000
Refinery production:						
Palladium, Pd content:						
Quantity	kilograms	5,660	7,410	7,650	7,820 [r]	7,920
Value	thousands	$58,700	$85,100	$87,300	$66,800 [r]	$135,000
Platinum, Pt content:						
Quantity	kilograms	6,870	8,930	7,400	7,210 [r]	6,500
Value	thousands	$253,000	$375,000	$376,000	$280,000	$338,000
Imports for consumption, refined:						
Iridium, Ir content	kilograms	2,800	3,410	2,550	1,520	3,530
Osmium, Os content	do.	56	23	11	68	76
Palladium, Pd content	do.	119,000	113,000	120,000	69,700	70,700
Platinum, includes waste, scrap, and coins, Pt content	do.	114,000	181,000	150,000	183,000	152,000
Rhodium, Rh content	do.	15,900	16,600	12,600	11,200	12,800
Ruthenium, Ru content	do.	36,000	48,700	49,800	21,200	14,100
Exports, refined:						
Iridium, osmium, and ruthenium, gross weight	do.	3,390	8,190	6,450	4,020	3,720
Palladium, Pd content	do.	53,100	41,800	26,400	30,300	38,100
Platinum, Pt content	do.	45,500	28,900	15,600	15,600	16,900
Rhodium, Rh content	do.	1,600	2,210	1,980	1,220	2,320
Stocks, National Defense Stockpile, December 31:						
Iridium, Ir content	do.	111	18	18	18	18
Platinum, Pt content	do.	261	261	261	261	261
Price, average:						
Iridium[3]	dollars per troy ounce	349.45	444.43	448.34	420.40	642.15
Palladium[4]	do.	322.93	357.34	355.12	265.65	530.61
Platinum[4]	do.	1,144.42	1,308.44	1,578.26	1,207.55	1,615.56
Rhodium[4]	do.	4,561.06	6,203.09	6,533.57	1,591.32	2,459.07
Ruthenium[3]	do.	193.09	573.74	324.60	97.28	198.45
Employment		1,720	1,630	1,360	1,270	1,350
World, mine production[e], PGM content	kilograms	515,000 [r]	511,000 [r]	468,000 [r]	449,000 [r]	467,000

[e] Estimated. [r] Revised. do. Ditto.

[1] Data are rounded to three significant digits, except prices.

[2] Source: Stillwater Mining Co., 2010 annual report, p. 52.

[3] Price data are annual averages of daily Engelhard unfabricated quotations published in Platts Metals Week.

[4] Price data are annual Engelhard unfabricated quotations published in Platts Metals Week.

TABLE 2

U.S. IMPORTS FOR CONSUMPTION OF PLATINUM, BY COUNTRY[1]

	Grain and nuggets		Sponge		Other unwrought		Other		Waste and scrap		Coins	
Country	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)
2009	16	$474	37,100	$1,420,000	3,770	$129,000	5,910	$174,000	136,000	$334,000	512	$20,500
2010:												
Argentina	9	306	--	--	6	399	1	69	169	8,690	--	--
Australia	--	--	--	--	--	--	467	24,200	6	214	11	625
Belgium	--	--	1,800	90,400	--	--	11	653	--	--	--	--
Bolivia	--	--	--	--	--	--	--	--	9,310	1,110	--	--
Brazil	--	--	222	10,500	--	--	(2)	17	3,260	17,800	--	--
Canada	5	197	--	--	1	13	240	12,600	15,800	65,400	16	789
Chile	--	--	--	--	--	--	--	--	977	188	--	--
China	--	--	--	--	--	--	14	441	1,670	24,900	--	--
Colombia	--	--	--	--	1,330	54,600	--	--	177	4,060	--	--
France	--	--	27	1,590	84	3,990	43	918	369	10,000	--	--
Germany	48	2,160	2,090	93,700	1,310	42,400	2,560	79,900	22,300	134,000	(2)	3
Hong Kong	--	--	--	--	--	--	(2)	6	300	496	--	--
India	--	--	64	3,110	4	179	7	394	65	3,060	--	--
Israel	--	--	--	--	65	1,730	--	--	59	2,010	--	--
Italy	--	--	1,800	93,100	--	--	88	4,970	384	22,800	--	--
Japan	--	--	69	3,650	70	2,160	11	262	21,500	83,800	--	--
Jordan	--	--	--	--	--	--	--	--	123	765	--	--
Korea, Republic of	--	--	212	11,300	43	2,630	19	1,400	696	30,800	--	--
Mexico	--	--	28	1,400	39	1,510	2	48	12,300	10,300	--	--
Norway	--	--	1,350	69,600	--	--	49	770	--	--	--	--
Russia	561	13,200	232	11,700	7	359	501	24,400	--	--	--	--
Saudia Arabia	--	--	--	--	--	--	--	--	2,080	73,100	--	--
Singapore	--	--	--	--	--	--	16	873	91	3,020	--	--
Slovakia	--	--	--	--	--	--	181	10,200	--	--	--	--
South Africa	1	64	20,100	1,010,000	8	392	149	7,280	--	--	(2)	9
Switzerland	--	--	99	5,140	808	40,200	126	5,950	--	--	(2)	6
Taiwan	--	--	110	5,700	4	216	2	32	1,270	19,900	--	--
United Kingdom	14	605	3,570	183,000	6	290	122	6,390	17,700	35,500	19	1,310
Other	4	209	--	--	7	254	38	793	501	13,100	(2)	19
Total	644	16,700	31,700	1,590,000	3,790	151,000	4,650	183,000	111,000	565,000	46	2,760

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3

U.S. IMPORTS FOR CONSUMPTION OF PLATINUM-GROUP METALS, BY COUNTRY[1]

Country	Unwrought palladium		Palladium, other		Iridium[2]		Osmium[2]		Ruthenium[2]		Rhodium[2]	
	Quantity, Pd content (kilograms)	Value (thousands)	Quantity, Pd content (kilograms)	Value (thousands)	Quantity, Ir content (kilograms)	Value (thousands)	Quantity, Os content (kilograms)	Value (thousands)	Quantity, Ru content (kilograms)	Value (thousands)	Quantity, Rh content (kilograms)	Value (thousands)
2009	62,300	$568,000	7,350	$62,300	1,520	$20,800	68	$551	21,200	$55,700	11,200	$530,000
2010:												
Austria	--	--	1	22	--	--	--	--	--	--	1	19
Belgium	431	7,490	--	--	1	69	--	--	--	--	747	60,900
Canada	1,340	30,600	1,350	33,100	--	--	--	--	--	--	(3)	2
China	197	3,700	27	522	--	--	16	117	--	--	(3)	3
France	72	251	--	--	--	--	--	--	--	--	--	--
Germany	4,450	72,500	150	1,960	235	3,330	--	--	1,930	7,300	1,250	88,900
Israel	--	--	50	343	--	--	--	--	--	--	--	--
Italy	1,880	33,700	277	5,610	20	344	--	--	--	--	108	7,300
Japan	2,290	18,600	107	1,030	6	127	--	--	439	2,830	191	14,200
Norway	4,170	64,700	--	--	--	--	--	--	--	--	130	9,470
Russia	15,100	241,000	3,110	58,200	--	--	--	--	--	--	1,790	91,800
South Africa	23,200	334,000	287	4,570	2,710	53,300	60	495	9,010	54,400	8,350	622,000
Switzerland	2,330	36,100	501	9,490	--	--	--	--	1	5	--	--
United Kingdom	8,960	147,000	453	7,500	549	8,740	--	--	2,740	17,900	265	19,400
Other	11	120	4	54	3	39	--	--	--	--	(3)	33
Total	64,400	990,000	6,310	122,000	3,530	65,900	76	612	14,100	82,500	12,800	914,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Unwrought and other forms.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
U.S. EXPORTS OF PLATINUM-GROUP METALS, BY COUNTRY[1]

	Palladium		Platinum		Platinum, waste and scrap		Iridium, osmium, ruthenium		Rhodium	
Country	Quantity, Pd content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, Pt content (kilograms)	Value (thousands)	Quantity, gross weight (kilograms)	Value (thousands)	Quantity, Rh content (kilograms)	Value (thousands)
2009	30,300	$229,000	15,600	$522,000	31,600	$523,000	4,020	$34,400	1,220	$48,400
2010:										
Argentina	6	10	83	3,910	--	--	--	--	--	--
Australia	772	8,240	21	982	(2)	3	5	73	--	--
Belgium	58	709	142	6,870	649	5,830	1	6	34	2,420
Brazil	645	10,700	34	1,620	--	--	--	--	42	3,080
Canada	4,730	39,800	1,130	56,200	44	1,880	10	139	1	98
China	1,830	25,900	451	19,900	62	3,500	561	7,000	813	48,900
Colombia	74	1,020	3	54	--	--	--	--	--	--
Czech Republic	739	1,500	--	--	--	--	--	--	--	--
Denmark	227	2,520	7	323	--	--	--	--	--	--
France	451	3,540	35	765	1	10	2	46	--	--
Germany	3,510	46,200	5,720	263,000	2,540	56,200	1,460	12,000	342	25,200
Hong Kong	1,100	15,300	113	5,120	(2)	36	82	1,170	231	14,000
India	232	1,540	309	15,700	--	--	3	35	9	652
Ireland	82	487	161	5,370	--	--	20	124	--	--
Israel	2,920	11,200	44	1,070	--	--	21	196	--	--
Italy	1,550	21,500	1,410	72,100	1	51	49	313	52	3,310
Japan	3,140	41,400	1,860	64,300	1,480	49,900	700	7,310	239	17,600
Korea, Republic of	1,480	17,600	82	3,590	--	--	2	26	4	369
Mexico	644	1,320	349	11,500	--	--	2	62	1	110
New Zealand	112	1,490	2	162	--	--	--	--	--	--
Norway	71	931	16	380	--	--	--	--	--	--
Saudi Arabia	43	442	1	13	--	--	--	--	262	7,450
Singapore	452	1,750	605	30,000	(2)	4	3	76	(2)	5
South Africa	83	345	53	1,120	4,620	23,000	1	21	7	865
Spain	203	1,400	1	39	--	--	1	9	--	--
Switzerland	7,090	108,000	2,990	156,000	6,560	169,000	1	16	9	765
Taiwan	2,190	18,200	59	2,280	--	--	640	4,810	8	750
Thailand	180	1,810	15	1,410	--	--	--	--	(2)	18
United Kingdom	3,330	32,700	1,060	44,500	22,200	791,000	151	3,280	261	5,910
Other	173	1,720	160	5,480	--	--	7	67	1	4,720
Total	38,100	419,000	16,900	775,000	38,200	1,100,000	3,720	36,800	2,320	136,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5
PLATINUM-GROUP METALS: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

Country[3]	2006	2007	2008	2009	2010
Palladium:					
Australia[4]	750	600	580 [r]	590 [r]	580
Botswana	2,000	5,000	3,000	3,000	3,330
Canada	10,493 [5]	14,100 [r]	14,700 [r]	8,100 [r]	6,700
Japan[6]	5,400	5,500	5,500	5,600	5,600
Poland[7, 8]	10	15	15	15	15
Russia	98,400	96,800	87,700	83,200 [5]	84,700
Serbia	15	15	15	15	15
South Africa[5]	86,265	83,643	75,537	75,118	82,222
United States[5, 9]	14,400	12,800	11,900	12,700	11,600
Zimbabwe	4,022 [5]	4,180 [5]	4,386 [5]	5,680	7,000
Total	222,000	223,000 [r]	203,000 [r]	194,000 [r]	202,000
Platinum:					
Australia[4]	209	142	120 [r]	130 [r]	130
Botswana	300	700	600	600	560
Canada	8,510 [r]	8,000 [r]	8,500 [r]	4,600	3,900
Colombia[5]	1,438	1,526	1,369 [r]	929 [r]	998
Ethiopia[10]	4	5 [5]	10 [5]	8 [r, 5]	8
Finland	800	800	800	800	800
Japan[6]	760	770	770	780	780
Poland[7, 8]	20	25	25	25	25
Russia	29,000	27,000	25,000 [r]	24,500 [r]	25,100
Serbia	2	2	2	2	2
South Africa[5]	168,125	160,940	146,140	140,819	147,790
United States[5, 9]	4,290	3,860	3,580	3,830	3,450
Zimbabwe	4,998 [5]	5,306 [5]	5,642 [5]	7,230	8,800
Total	218,000 [r]	209,000 [r]	193,000 [r]	184,000 [r]	192,000
Other platinum-group metals:					
Canada	5,000	4,000	4,000	2,600	2,600
Russia	15,600	14,500	12,500	11,900	12,000
South Africa[5]	53,138	59,449	53,999	55,456 [r]	57,292
Zimbabwe	864 [5]	1,695 [5]	1,804 [5]	800	1,300
Total	74,600	79,600	72,300	70,800	73,200
Grand total	515,000 [r]	511,000 [r]	468,000 [r]	449,000 [r]	467,000

[r] Revised.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 20, 2011. Platinum-group metal (PGM) production by Germany, Norway, and the United Kingdom is not included in this table because the production is derived wholly from imported metallurgical products and to include it would result in double counting.

[3] In addition to the countries listed, China, Indonesia, and the Philippines are thought to produce PGM, and several other countries may also do so, but output is not reported quantitatively, and there is no reliable basis for the formulation of estimates of output levels. A part of this output not specifically reported by country is, however, presumably included in this table credited to Japan.

[4] PGM recovered from nickel ore that is processed domestically. PGM in exported nickel ore are extracted in the importing countries, such as Japan, and are thought to be included in the production figures for those countries.

[5] Reported figure.

[6] Production derived entirely from imported ores.

[7] Based on official Polish estimates.

[8] Estimates based on reported platinum- and palladium-bearing final (residual) slimes and then average Pt and Pd content from electrolytic copper refining.

[9] A very small quantity of byproduct platinum and palladium produced from gold-copper ores was excluded.

[10] Data for the Ethiopian calendar year ending July 7 of that stated. Yubdo Mine only. Platinum was also reportedly contained in gold

POTASH

By Stephen M. Jasinski

Domestic survey data and tables were prepared by Christopher H. Lindsay, industry data analyst, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, the world potash markets recovered from the economic downturn, with consumption and production returning to levels seen before 2008. Domestic production increased by 29% to 930,000 metric tons (t) potassium oxide (K_2O) in 2010 from 720,000 K_2O equivalent in 2009. U.S. sales of potash increased by nearly 60% from that of 2009; and apparent consumption more than doubled to 5.6 million metric tons (Mt) in 2010 from 2.5 Mt in 2009 (table 1). World production of potash increased by 64% from that of 2009.

Potash includes a variety of mined and manufactured salts, all of which contain the element potassium in water-soluble form. The majority of domestic potash was produced near Carlsbad, NM, with most of the potash coming from the mineral sylvite. The term potash refers to potassic fertilizers, which are potassium chloride (KCl or sylvite), potassium sulfate [K_2SO_4 or sulfate of potash (SOP), usually a manufactured product], and potassium-magnesium sulfate [$K_2SO_4 \bullet 2MgSO_4$ or langbeinite or double sulfate of potash magnesia (SOPM or K-Mag)]. Muriate of potash (MOP) is an agriculturally acceptable mix of KCl (95% pure or greater) and sodium chloride (halite) for fertilizer use that includes minor amounts of other nontoxic minerals from the mined ore and is neither the crude ore sylvinite nor pure sylvite.

Production

Domestic production data were developed by the U.S. Geological Survey (USGS) from a semiannual voluntary canvass of U.S. operations. All of the seven operations canvassed for semiannual production data responded to the surveys.

Potash companies in the United States produced MOP, SOP, and SOPM. Published production data of all types and grades of potash in the United States are adjusted to avoid disclosing the proprietary data of companies that produce SOP and SOPM, which together are known as sulfates

Three companies produced potash from seven operations in three States. Most domestic production was from southeastern New Mexico, where Intrepid Potash, Inc. operated two mines and The Mosaic Company operated one mine. Mosaic also operated a deep-solution mine in Michigan. The third State with potash production was Utah, where Intrepid produced potash from a solution mine in Moab and from a solar evaporation facility in Wendover; Great Salt Lake Minerals Corp. (GSLM) (a subsidiary of Compass Minerals International, Inc.) operated a solar evaporation facility in Ogden.

Intrepid continued to develop the HB Solar Solution Mine in Carlsbad, NM. The mine was operated previously as a conventional underground potash mine. Intrepid planned to convert the HB mine into a solution mine. In 2010, the U.S. Bureau of Land Management (BLM) began the environmental impact statement (EIS) required for approval of the project. The final EIS was expected to be released in late 2011 or early 2012. In July 2010, Intrepid received the ground water discharge permit for the mine from the New Mexico Environment Department. The company expected to begin production about 18 months after receiving approval for the project and gradually increase production to full capacity of 200,000 metric tons per year (t/yr) about 1 year after commencing operations (Intrepid Potash, Inc., 2011, p. 7).

GSLM began work in September on the expansion of its SOP production capacity to 570,000 t/yr from 350,000 t/yr. By using new technology to improve the efficiency of its solar evaporation process, the company would increase capacity without adding new evaporation ponds on the Great Salt Lake. The project was to be completed incrementally through 2015. GSLM previously announced plans to double its SOP capacity by adding 36,800 hectares of new solar evaporation ponds. The company applied for permits in 2007 with the U.S. Army Corps of Engineers, which continued conducting environmental studies of the expansion parcel (Overbeck, 2010).

Exploratory drilling for potash began in Burke County, ND, in November. Dakota Salts LLC (a subsidiary of Sirius Exploration PLC) received the first potash exploration permit issued in North Dakota since 1976. The potash deposits in the State are contiguous with those in the Canadian Provinces of Manitoba and Saskatchewan; however, the potash beds in North Dakota are much deeper than those in Canada. The average depth of mines in Saskatchewan is 1,500 meters (m), and the exploratory well in North Dakota was drilled to a final depth of 2,794 m. Dakota Salts planned to recover the potash by solution mining if the project is determined to be feasible (MacPherson, 2010).

Consumption

The principal use of potash is as an agricultural fertilizer (plant nutrient) because it is a source of soluble potassium, which is one of the three primary plant nutrients required for plant growth and maturation; the others are fixed nitrogen and soluble phosphorus. Potash and phosphorus are mined products, and fixed nitrogen is produced from the atmosphere using industrial processes. Modern agricultural practice uses large amounts of these primary nutrients and additional nutrients, such as boron, calcium, chlorine, copper, iron, magnesium, manganese, molybdenum, sulfur, and zinc, to ensure plant health and proper maturation. The three major plant nutrients have no cost-effective substitutes. Low-nutrient-content alternative potash sources, such as animal manure and guano, bone meal, compost, glauconite, and "tankage" from slaughterhouses, are available, but the cost of transportation per metric ton of nutrient beyond relatively short distances can reduce their desirability. In addition to its use as a fertilizer, potassium chloride is important in industrialized economies, where it is used in aluminum recycling, by the chloralkali industry to produce potassium hydroxide, in metal electroplating, in oil-well drilling mud, in snow and ice melting, in steel heat-treating, and in water softening.

Potassium hydroxide is used for industrial water treatment and is the precursor of potassium carbonate, several forms of potassium phosphate, many other potassic chemicals, and soap manufacturing. Potassium carbonate is used to produce animal feed supplements, cement, fire extinguishers, food products, photographic chemicals, and textiles. It is also used in brewing beer, pharmaceutical preparations, and as a catalyst for synthetic rubber manufacturing. Generally, these nonfertilizer uses have accounted for about 15% of annual potash consumption in the United States and 10% worldwide.

Foreign Trade

Imports for consumption of all potash fertilizers, in term of K_2O content, more than doubled from those of 2009, owing to a recovery in the potash market following the economic downturn in 2008–09. The largest increase was for MOP imports, which increased by 118% from those of 2009. Overall, 84% of imports of SOPM were from Canada (tables 5–6). Potash exports were slightly lower than that in 2009, although exports of SOPM were 56% higher, in terms of K_2O content (tables 3–4).

World Industry Structure

World production of potash increased to 33.7 Mt from 20.6 Mt in 2009. Canada, Russia, and Belarus, the leading producers by order of output, accounted for 63% of world production in 2010 (table 7).

World Review

Canada.—The three current potash producers in Canada, Agrium Inc., Mosaic, and Potash Corp. of Saskatchewan Inc. (PotashCorp) planned to expand production capacity in the near future. Agrium expected to complete expansion of its Vanscoy Mine in Saskatchewan by 2012, which would increase its production capacity by 0.8 million metric tons per year (Mt/yr) of MOP (Agrium Inc., 2011, p. 22). Mosaic had several projects planned or in progress that would increase its production capacity in Saskatchewan to 14.8 Mt/yr of MOP by 2019 from 9.9 Mt/yr of MOP in 2010 (Mosaic Company, The, 2011, p. 11–13). PotashCorp had ongoing expansion projects at its mines in New Brunswick and Saskatchewan that were scheduled to add 3.2 Mt/yr of MOP production capacity in 2012. In addition, PotashCorp was building a new mine at Rocanville, Saskatchewan, that would add 2.7 Mt/yr of MOP capacity. All projects were expected to increase the company's MOP production capacity to 17.9 Mt/yr in 2015 from 13.3 Mt/yr (Potash Corp. of Saskatchewan Inc., 2011, p. 4–6).

Several foreign companies have acquired potash properties in Saskatchewan since 2008 and were actively developing new mines. In 2010, BHP Billiton Group (Melbourne, Australia) completed a feasibility study of its Jansen Project, which it acquired from Anglo Potash Inc. in 2008. The Jansen Mine was planned to have production capacity of 8 Mt/yr of MOP. BHP planned to begin active development by 2012. In January 2010, BHP acquired Athabasca Potash Inc., which was developing the Burr Potash Project next to the Jansen property. BHP did not give a timeframe for development of the Burr property. BHP controls about 6,900 square kilometers of potash properties in Saskatchewan (Fertilizer International, 2010b). BHP also made a bid to acquire PotashCorp, but it withdrew the offer after the bid was rejected by the Canadian Minister of Industry (Green Markets, 2010a).

Vale S.A. (Brazil), acquired the Regina Potash property from Rio Tinto Plc (London, U.K.) in late 2009. Vale planned to construct a 2.8-Mt/yr MOP mine that would begin production after 2016 (Green Markets, 2010c).

German potash producer, K+S Aktiengesellschaft, purchased Potash One Inc. in late 2010 to gain control of the Legacy Potash Project. Potash One completed a feasibility study and EIA prior to its sale to K+S. The new solution mine was planned to produce 2.86 Mt/yr of MOP for about 40 years. K+S expected to start construction of the mine in late 2011 (Fertilizer Week, 2010).

Western Potash Corp. was developing the Milestone property, near the BHP Jansen Property. The company planned to construct a 2-Mt/yr MOP solution mine within the next decade (Fertilizer International, 2010b).

Congo (Brazzaville).—Three mines in Congo (Brazzaville) were in various stages of development in 2010. The Kouilou Project, which was being developed by MagIndustries Corp. of Canada through its subsidiary (MagMinerals Potasses Congo SA) was the most advanced in terms of permitting and feasibility. MagIndustries planned to build a solution mine with an initial production capacity of 600,000 t/yr of MOP and increase it to 1.2 Mt/yr. MagIndustries signed an agreement with China National Complete Plant Import and Export Co. Ltd. (COMPLANT) for investment and construction funding for the mine and processing facilities (Green Markets 2010b).

The other companies, Elemental Minerals Ltd. and Congo Potash Co., were planning to develop solution mines that would begin production in 2013 to 2015 (Fertilizer International, 2010a).

Russia.—Russian potash producers OJSC Silvinit and OJSC Uralkali announced plans to merge in the fourth quarter of 2010. The new company would take the Uralkali name and become one of the world's leading producers of potash. The merger was expected to be approved by the shareholders and Russian regulatory agencies in 2011 (Fertilizer Week, 2011).

Outlook

World potash production and consumption are projected to continue to recover from the economic downturn that lasted into 2009. According to the International Fertilizer Industry Association, potash production was projected to increase in 2011 by 6% from that in 2010 and by another 5% in 2012. World potash consumption was projected to increase in 2011 by 7% from that of 2010 and by an additional 3% in 2012. Annual potash production capacity was planned to increase in 2012 to 46.8 Mt/yr K_2O from 42.5 Mt/yr K_2O in 2010 (Heffer and Prud'homme, 2011).

Potash exploration and development is expected to remain very active during the next decade. Significant new mines are projected to startup before 2025 in Argentina, Australia, Brazil, Chile, China, Eritrea, Ethiopia, Kazakhstan, Laos, Turkmenistan, the United Kingdom, and Uzbekistan.

Potash is an essential fertilizer nutrient that cannot be substituted. More than 90% of world consumption is in fertilizer products. Increasing world population and its need for food will require continued increases in both potash production and consumption.

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TABLE 1

SALIENT POTASH STATISTICS[1, 2]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2006	2007	2008	2009	2010
United States:						
Production:[3]						
Gross weight		2,400	2,600	2,500	1,700	2,200
K_2O equivalent		1,100	1,100	1,100	720	930
Sales by producers:						
Quantity:[3]						
Gross weight		2,400	2,600	2,400	1,500	2,400
K_2O equivalent		1,100	1,200	1,100	630	1,000
Value[3, 4]		410,000	480,000	740,000	500,000	660,000
Average value:[5]						
Gross weight	dollars per metric ton	170	185	305	330	275
K_2O equivalent	do.	380	410	675	800	605
Exports:						
Gross weight		809	510	694	705	813
K_2O equivalent		332	199	222	303	297
Imports for consumption:[6, 7]						
Quantity:						
Gross weight		7,380	8,190	9,560	3,670	7,840
K_2O equivalent		4,470	4,970	5,800	2,220	4,760
Value, customs		1,150,000	1,310,000	3,260,000	1,720,000 r	2,620,000
Consumption, apparent:[3, 8]						
Gross weight		9,000	10,000	11,000	4,500	9,400
K_2O equivalent		5,200	5,900	6,700	2,500	5,600
World, production, marketable K_2O equivalent		30,400	34,900 r	33,700 r	20,600 r	33,700 e

e Estimated. r Revised. do. Ditto.

[1] Includes muriate of potash, sulfate of potash, potassium magnesium sulfate, and some parent salts. Excludes other chemical compounds that contain potassium.

[2] Data are rounded to no more than three significant digits unless otherwise specified.

[3] Data are rounded to no more than two significant digits.

[4] Free on board mine.

[5] Rounded to the nearest $5 to avoid disclosing proprietary data.

[6] Excludes potassium chemicals and mixed fertilizers.

[7] Includes nitrate of potash.

[8] Calculated from sales plus imports minus exports.

TABLE 2
PRICES OF U.S. POTASH, BY TYPE AND GRADE[1, 2]

(Dollars per metric ton of K_2O equivalent)

	2009			2010		
Type and grade	January–June	July–December	Yearly average	January–June	July–December	Yearly average
Muriate, 60% K_2O minimum:						
Standard	1,300	650	870	1,320	650	880
Granular	775	550 [r]	620	550	555	550

[r] Revised.

[1] Average prices, free on board mine, based on sales.

[2] Data rounded to nearest $5.

TABLE 3
U.S. EXPORTS OF POTASH, BY TYPE[1]

	Approximate average K_2O equivalent content (percentage)	Quantity (metric tons)	
		Gross weight	K_2O equivalent[e]
2009:			
Potassium chloride, all grades	61	342,000	208,000
Potassium sulfate	51	42,400	21,600
Potassium magnesium sulfate	22	313,000	68,800
Potassium nitrate	45	8,450	3,800
Total	XX	705,000	303,000
2010:			
Potassium chloride, all grades	61	248,000	151,000
Potassium sulfate	51	66,300	33,800
Potassium magnesium sulfate	22	489,000	108,000
Potassium nitrate	45	9,990	4,500
Total	XX	813,000	297,000

[e] Estimated. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 4
U.S. EXPORTS OF POTASH, BY COUNTRY [1]

(Metric tons of product)

Country	Potassium chloride		Potassium sulfates, all grades[2]		Potassium nitrate		Total	
	2009	2010	2009	2010	2009	2010	2009	2010
Argentina	7	7	109	4,900	--	--	116	4,910
Australia	--	19	8	14,100	534	552	542	14,700
Barbados	107	912	--	221	39	7	146	1,140
Belize	--	2,180	24	641	129	95	153	2,920
Brazil	225,000	119,000	15,000	15,600	10	106	240,000	135,000
Canada	5,520	5,050	51,800	114,000	1,350	719	58,700	120,000
Chile	4,630	10,600	37,000	47,700	--	57	41,700	58,400
China	3	58	379	17,500	2	--	384	17,600
Colombia	12,200	9,940	32,900	37,300	--	3	45,000	47,300
Costa Rica	19,700	4,100	27,300	30,700	1	--	47,000	34,800
Côte d'Ivoire	--	1,010	--	5,490	--	--	--	6,510
Dominican Republic	4,230	1,530	1,880	4,090	--	--	6,100	5,620
Ecuador	4,140	4	8,600	9,230	--	--	12,700	9,230
El Salvador	3,860	2,530	1	2,500	--	--	3,860	5,030
Ghana	3,130	2,000	8,190	23,300	--	--	11,300	25,300
Guadeloupe	1,200	2,300	715	1,650	--	--	1,910	3,950
Guatemala	6,100	6,510	3,770	24,600	--	--	9,870	31,100
Honduras	3,930	18,600	11,300	13,100	6	--	15,300	31,700
India	8	16	19,700	17,600	1	--	19,700	17,600
Japan	591	1,100	44,100	39,700	--	65	44,700	40,900
Korea, Republic of	102	13,900	6,460	--	79	41	6,640	13,900
Martinique	1,000	5,700	825	1,570	--	--	1,830	7,270
Mexico	36,400	31,200	40,300	56,100	2,550	5,670	79,200	93,000
Netherlands	39	4	--	235	3,200	1,500	3,230	1,740
New Zealand	--	--	7,050	6,000	--	--	7,050	6,000
Nicaragua	--	--	2,070	2,800	--	--	2,070	2,800
Panama	--	--	3	3,520	--	--	3	3,520
Peru	7,200	7,500	6,010	25,000	--	--	13,200	32,500
Thailand	140	569	--	5	204	577	344	1,150
Trinidad and Tobago	1,840	41	32	--	--	--	1,870	41
United Kingdom	11	6	5,420	130	--	--	5,430	136
Venezuela	--	--	23,600	32,800	--	--	23,600	32,800
Vietnam	--	--	--	1,960	--	--	--	1,960
Other	630 r	1,130	394 r	553	355 r	598	1,380 r	2,280
Total	342,000	248,000	355,000	555,000	8,450	9,990	705,000	813,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes potassium magnesium sulfate.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF POTASH, BY TYPE[1]

	Approximate average K_2O equivalent content (percentage)	Quantity (metric tons)		Value (thousands)	
		Gross weight	K_2O equivalent[e]	Customs	C.i.f.[2]
2009:					
Potassium chloride[3]	61	3,510,000	2,140,000	$1,610,000	$1,630,000
Potassium sulfate	51	87,600	44,700	63,700	65,900
Potassium nitrate	45	73,900 [r]	33,200 [r]	47,900 [r]	48,500 [r]
Potassium sodium nitrate mixture	14	658	92	265	274
Total	XX	3,670,000	2,220,000	1,720,000 [r]	1,750,000 [r]
2010:					
Potassium chloride[3]	61	7,660,000	4,670,000	2,530,000	2,590,000
Potassium sulfate	51	99,400	50,700	41,600	44,300
Potassium nitrate	45	76,900	34,600	44,900	45,700
Potassium sodium nitrate mixture	14	353	49	245	250
Total	XX	7,840,000	4,760,000	2,620,000	2,680,000

[e] Estimated. [r] Revised. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight.

[3] Contains imports listed under Harmonized Tariff Schedule of the United States code 3104.10.0000.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF POTASH, BY COUNTRY[1]

	Potassium chloride (metric tons)		Potassium sulfate (metric tons)		Potassium nitrate (metric tons)		Potassium sodium nitrate (metric tons)		Total					
									Quantity (metric tons)		Value (thousands)			
											Customs		C.i.f.[2]	
Country	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Belgium	2	2	5,200	74	10	--	--	--	5,210	76	$3,910	$44	$4,110	$46
Canada	3,220,000	6,560,000	21,000	25,500	--	42	199	333	3,240,000	6,590,000	1,490,000	2,140,000	1,500,000	2,180,000
Chile	11,200	3,600	5,630	5,300	64,200 r	64,400	--	--	81,000 r	73,300	56,400 r	44,800	56,900 r	45,100
China	48,800	--	6	127	399	749	1	12	49,200	888	23,400	310	24,500	347
France	--	--	1,650	2,340	43	730	--	--	1,690	3,070	347	597	376	646
Georgia	--	15,000	--	--	--	--	--	--	--	15,000	--	5,740	--	5,740
Germany	23,300	16,000	54,100	61,900	5,260	4,970	432	--	83,100	82,800	44,800	28,300	46,500	30,700
India	50	2	2	3	32	81	--	--	84	86	78	64	85	68
Israel	9,210	71,000	--	--	1,820	3,150	--	--	11,000	74,200	1,700	30,600	1,960	32,000
Japan	--	--	48	57	1,900	1,840	--	--	1,940	1,900	630	638	662	671
Jordan	--	--	--	--	61	194	--	--	61	194	28	57	28	58
Latvia	--	21,200	--	--	--	--	--	--	--	21,200	--	7,880	--	7,880
Lithuania	--	1,770	--	--	--	--	--	--	--	1,770	--	235	--	238
Mexico	--	--	1	64	107	76	--	--	108	140	46	61	48	66
Russia	194,000	969,000	--	--	--	--	--	--	194,000	969,000	104,000	358,000	110,000	378,000
Spain	--	--	56	3,830	--	--	--	--	56	3,830	94	278	102	281
United Kingdom	2,270	2,590	--	--	42	21	21	--	2,340	2,610	239	264	245	271
Other	4 r	2	-- r	204	9 r	582	5 r	8	18 r	796	31 r	318	34 r	366
Total	3,510,000	7,660,000	87,600	99,400	73,900 r	76,900	658	353	3,670,000	7,840,000	1,720,000 r	2,620,000	1,750,000 r	2,680,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 7

MARKETABLE POTASH: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons of K_2O equivalent)

Country	2006	2007	2008	2009	2010[e]
Belarus	4,605	4,972	4,968	2,485	5,250
Brazil	403	424	383	453	453
Canada	8,518	11,085	10,379	4,297	9,788 [3]
Chile	496	515	559	691 [r]	800
China[e]	1,800	2,600	2,750	3,000	3,200
Germany	3,625	3,637	3,280	1,825 [r]	3,000
Israel	2,187	2,182	2,170	1,900 [r]	1,960
Jordan	1,036	1,096	1,223	683	1,200
Russia[e]	5,740 [r]	6,430 [r]	5,990 [r]	3,730 [r]	6,280
Spain[e]	435 [3]	435	435	400 [r]	415
Ukraine	-- [r]	-- [r]	-- [r]	-- [r]	--
United Kingdom	420	427	427 [e]	427 [e]	427
United States[4]	1,100	1,100	1,100	720	930 [3]
Total	30,400	34,900 [r]	33,700 [r]	20,600 [r]	33,700

[e] Estimated. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 12, 2011.

[3] Reported figure.

[4] Rounded to no more two significant digits.

PUMICE AND PUMICITE

By Robert D. Crangle, Jr.

Domestic survey data and tables were prepared by Paula R. Neely, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, U.S. pumice and pumicite production was 390,000 metric tons (t). This was a decrease of 5% compared with that of 2009, when the United States produced 410,000 t. The overall value of pumice production in 2010 was $7.81 million, a decrease of 37% from that in 2009. The observed decrease in total production, and particularly in value, came as a result of the stagnant U.S. housing and construction industries, where pumice is used in building blocks, concrete, and landscaping. The apparent consumption of pumice and pumicite in the United States in 2010 was 411,000 t, a decrease of 3% compared with that of 2009. Imports increased by 35% to 34,000 t. Exports of 13,000 t represented an increase of approximately 19% compared with 11,000 t of exported pumice and pumicite in 2009 (table 1). Pumice imports and exports represent relatively small amounts of U.S. apparent consumption and are subject to large annual fluctuations in terms of percentage.

Pumice is an extrusive igneous volcanic rock formed through the cooling of air-pocketed lava, which results in a highly porous, low-density rock (Presley, 2006). The low density allows some pumice to float on water. Large pumice rafts, a unique geologic phenomenon, have been documented to be as long as 30 kilometers (km) and to drift for several years in oceanic waters (Wood-Jones, 1910, p. 290–291; Bryan and others, 2004, p. 136). Pumicite is defined as grains, flakes, threads, and (or) shards of volcanic glass finer than 4 millimeters in diameter (Harben and Bates, 1984, p. 64). Pumicite and volcanic ash are descriptive terms that are often interchangeably used.

The porous, lightweight properties of pumice are well suited for its main use as an aggregate in lightweight building blocks and assorted building products. In 2010, other major applications included abrasives, horticulture (including landscaping), and stonewashing of denim. Minor applications incorporated the use of pumice as an absorbent, as a concrete aggregate and admixture, as a filter aid, and as a traction enhancer for tires. A small percentage of pumice was used in abrasive-type products, including pencil erasers, a polishing agent for circuit boards and television monitors, an exfoliant in cosmetics, and a variety of heavy-duty hand cleaners. Imports were primarily used as raw material for blocks and as a lightweight aggregate.

Production

Domestic production data for pumice and pumicite were developed by the U.S. Geological Survey (USGS) from an annual voluntary review of U.S. pumice- and pumicite-producing sites and company operations. The canvass for 2010 included 11 companies with 14 active operations that produced, used, or sold pumice and pumicite in the United States. Ten of the 11 companies responded to the canvass. Data from the single nonrespondent producer was estimated from reported prior-year information adjusted to current employment and consumption trends, coupled with Mine Safety and Health Administration employment records. Data were rounded to no more than three significant digits. All percentages in this report were computed based on unrounded data.

U.S. pumice and pumicite production of 390,000 t was valued at $7.81 million. States that produced pumice and pumicite, in order of decreasing production, were Nevada, Oregon, Idaho, Arizona, California, New Mexico, and Kansas.

Pumice is usually extracted by simple open pit methods using rippers, bulldozers, and front-end loaders. Processing is typically limited to drying, crushing, and screening, although some abrasive grades may require fine grinding and classification. Pumice blocks may be sawn into a variety of shapes and sizes.

Consumption

In 2010, more than 270,000 t, or 69% of the pumice and pumicite produced in the United States, was used for building and decorative blocks (table 2). This was a 13% increase from that of 2009. Pumice used for horticultural and landscaping purposes in 2010 decreased by 41% to 60,000 t from the 2009 reported total of 101,000 t. Horticultural and landscaping applications accounted for 15% of total consumption in 2010. Pumice and pumicite for concrete admixture and aggregate decreased by 41% to 16,000 t in 2010 from 28,000 t in 2009 and accounted for 4% of consumption. Pumice used as an abrasive in 2010 increased by 181% to a total of 23,000 t, which accounted for 6% of consumption. The large increase in 2010 was a result of changes in relatively small tonnages, which are subject to large annual variations. The amount of pumice reported sold or used by several low-volume markets or for unreported uses grouped in the "other" category decreased by 39% to 20,000 t in 2010 from 34,000 t in 2009 and accounted for 5% of consumption. "Other" uses nominally included absorbent (including pet litter), cosmetics, diluents, engineered fill, filter aids, geotechnical aids, pottery clays, highway snow control, road construction, and other unspecified uses. There are several substitutes for pumice in agriculture, horticulture, as an aggregate, as a concrete additive, and other end products.

Prices

As a result of the small number of pumice producers, coupled with producer-specific end-use products, the average prices reported for pumice and pumicite in 2010 varied greatly by use compared with the average price for all uses in 2009. The overall average prices reported for all pumice and pumicite products decreased by 33% to $20.00 per metric ton in 2010 from $29.97 per ton in 2009. The price change reflected the decreases in unit values of building block, concrete admixture and aggregate, and horticulture and landscaping products. The unit value of the building block and decorative use category decreased by 48% to $12.05 per ton in 2010 from $23.13 per ton in 2009. This decrease in value was likely the result of an overall production increase coupled with a weaker market compared with that in 2009. The average price for pumice and pumicite used for horticultural and landscaping decreased by 52% to $14.11 per ton in 2010 from $29.57 per ton in 2009. The average price in 2010 for pumice and pumicite used in nonspecialty abrasive applications was $10.25 per ton, an increase of 9% from the reported amount of $9.38 per ton in 2009. For concrete admixture and aggregates, $29.12 per ton was reported for 2010, a decrease of 3% from the 2009 value of $29.93 per ton. For other uses, the 2010 unit value of $146.36 per ton was 72% more than the $84.97 unit value reported in 2009 (table-2).

Foreign Trade

Export and import data presented here, which are from the U.S. Census Bureau, are of limited accuracy. This is a result of inconsistencies in producer reporting, coupled with a lack of detail for materials specified in the 2010 Harmonized Tariff Schedule of the United States (HTS), as issued by the U.S. International Trade Commission. The trade data were published under subheading 2513.10 of the HTS, described as applying to pumice stone. Industry sources, however, indicated that pumice may be included under the general heading 2513, which included corundum garnets and other natural abrasives.

Exports of pumice, mostly specialty products, increased to approximately 13,000 t, with a value of $5.97 million in 2010, or about $456 per ton. This was an 18% decrease in tonnage from the 11,000 t valued at $5.1 million in 2009. Canada accounted for 29% of 2010 exports, followed by Hong Kong with 13%, China with 11%, Italy with 8%, and the United Kingdom with 7%. Small amounts of pumice and pumice products were exported to 62 other countries.

Imports of crude or unmanufactured pumice and pumicite in 2010 increased by 34% to 35,000 t compared with 26,000 t reported in 2009. By volume, most imports of pumice and pumicite were raw materials for blocks and lightweight aggregate in construction-related uses, with smaller amounts used in a range of abrasives and for stonewashing denim. Ninety-five percent of imported crude pumice came from Greece (table 3), which supplied 33,200 t of crude pumice to the United States in 2010 and remained the leading source of pumice imports. Pumice from Mexico totaled 1,300 t, or 4% of total imported pumice, in 2010. Sixteen other countries supplied small amounts of pumice and pumicite in 2010.

World Review

Pumice is used more extensively as a building material outside the United States, which helps to explain the large global production and sales of pumice. In Europe, basic home construction uses significantly less gypsum wallboard because stone and concrete are the preferred building materials. Prefabricated lightweight concrete walls are often produced and shipped to construction locations. Because of their lightweight, strength, and cementitious properties, pumice and pumicite perform well in European-style construction. In 2010, Greece was the leading exporter of pumice to Asia, Europe, and the United States.

Outlook

U.S. consumption of pumice and pumicite in 2011 was expected to remain static compared with that of 2010, largely owing to the status of the U.S. residential housing sector, a major user of pumice- and pumicite-related products.

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TABLE 1
SALIENT PUMICE AND PUMICITE STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

	2006	2007	2008	2009	2010
United States:					
Sold and used by producers:					
Quantity	1,540	1,270	791	410	390
Value[2]	44,300	28,900	15,900	12,300	7,810
Average value dollars per metric ton	28.85	22.85	20.13	29.97	20.00
Exports[3]	18	9	15	11	13
Imports for consumption[3]	109	37	65	26	35
Apparent consumption[4]	1,630	1,290	841	425	412
World, production, pumice and related volcanic materials	19,900 r	20,700	18,400 r	17,800 r	17,300 e

eEstimated. rRevised.

[1] Data are rounded to no more than three significant digits, except average value.

[2] Free on board mine and (or) mill.

[3] Source: U.S. Census Bureau.

[4] Production plus imports minus exports plus adjustments for Government and industry stock changes.

TABLE 2
PUMICE AND PUMICITE SOLD AND USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

	2009			2010		
Use	Quantity (thousand metric tons)	Value (thousands)	Average unit value	Quantity (thousand metric tons)	Value (thousands)	Average unit value
Abrasives[2]	8	$78	$9.38	23	$239	$10.25
Building block, includes decorative block	239	5,540	23.13	270	3,260	12.05
Concrete admixture and aggregate	28	826	29.93	16	476	29.12
Horticulture and landscaping	101	2,980	29.57	60	842	14.11
Other[3]	34	2,870	84.97	20	2,990	146.36
Total or average	410	12,300	29.97	390	7,810	20.00

[1] Data are rounded to no more than three significant digits, except average unit value; may not add to totals shown.

[2] Includes cleaning and scouring compounds.

[3] Includes absorbent, diluents, fill, filter aids, laundries, pottery, and other unspecified uses.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF PUMICE, BY CLASS AND COUNTRY[1]

	Crude or unmanufactured		Wholly or partly manufactured	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009:				
Austria	--	--	(2)	$11
China	9	$49	74	307
Germany	--	--	68	70
Greece	21,000	367	20	289
Italy	--	--	(2)	3
Mexico	1,360	209	86	19
Montserrat	3,600	130	--	--
Poland	--	--	6	98
Other	68	29	4	35
Total	26,000	784	258	832
2010:				
Austria	--	--	(2)	8
China	9	40	54	278
Germany	--	--	231	131
Greece	33,200	556	41	569
Iceland	--	--	236	236
Japan	28	16	35	37
Mexico	818	146	516	118
Turkey	--	--	19	19
Other	--	--	5	33
Total	34,100	758	1,140	1,430

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
PUMICE AND RELATED MATERIALS: WORLD PRODUCTION, BY COUNTRY[1,2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Algeria, pozzolan	433,190	570,000	490,567	328,000 [r]	450,000 [4]
Argentina, pumice	17,665	16,200	6,500	7,020 [4]	7,000
Burkina Faso[e]	10,000	10,000	10,000	10,000	10,000
Cameroon, pozzolan[e]	600,000	600,000	600,000	600,000	600,000
Chile, pumice and pozzolan	1,423,144	1,135,771	1,063,176	919,249 [r]	915,000
Costa Rica[e]	8,000	--	--	--	--
Croatia, volcanic tuff	17,157	15,085	15,000 [e]	15,000 [e]	15,000
Dominica, pumice and volcanic ash[e]	100,000	100,000	100,000	100,000	100,000
Ecuador:					
Pozzolan	700,007	582,560	580,000 [r, e]	580,000 [r, e]	580,000
Pumice	8,730	153,500	100,000 [r, e]	100,000 [e]	100,000
El Salvador, pozzolan[e]	223,000	223,000	223,000	200,000	NA
Eritrea, pumice	1,072	55	60 [e]	60 [e]	60
Ethiopia[5]	255,622	22,000	35,000	58,000 [r]	60,000
France, pozzolan and lapilli[e]	272,000	250,000	276,000	276,000	276,000
Greece:[e]					
Pozzolan, Santorin earth	1,400,000	1,400,000	1,059,000 [4]	830,000	900,000
Pumice	850,000	850,000	828,000 [4]	381,000	380,000
Guadeloupe, pumice[e]	210,000	210,000	210,000	200,000	200,000
Guatemala, pumice	-- [r]	220,389	393,779 [r]	394,955	400,000
Honduras, pozzolan[e]	100,000	100,000	100,000	100,000	--
Iceland:[e]					
Pumice	105,000 [4]	100,000	100,000	100,000	100,000
Scoria	1,000	1,000	1,000	1,000	1,000
Iran[e]	1,400,000	1,500,000	1,500,000	1,500,000	1,500,000
Italy:[e]					
Pozzolan	4,000,000	4,000,000	3,000,000	3,000,000	3,000,000
Pumice and pumiceous lapilli	20,000	20,000	20,000	20,000	20,000
Jamaica, pozzolan	149,279	114,482	124,304	132,470	125,000
Kosovo, volcanic tuff	-- [6]	-- [6]	45,005 [r, 7]	58,788 [r, 7]	60,000
Macedonia, volcanic tuff	60,000 [e]	80,910	103,476	113,064	113,000
Martinique, pumice[e]	130,000	130,000	130,000	130,000	130,000
New Zealand	303,659	354,903	174,729	159,357 [r]	160,000
Philippines:					
Pumice	1,917	1,912	2,063	2,064	2,100
Volcanic tuff	17,590	16,490	17,570	18,830	20,000
Saudi Arabia, pozzolan[e]	400,000	784,000 [4]	810,000	800,000	800,000
Serbia, volcanic tuff[e]	100,000	100,000	100,000	100,000	100,000
Slovenia, volcanic tuff[e]	40,000	40,000	40,000	40,000	40,000
Spain, including Canary Islands[e]	600,000	600,000	600,000	600,000	600,000
Syria, volcanic tuff[e]	650,000	810,000	901,000 [4]	957,639 [4]	950,000
Tanzania, pozzolanic materials	129,295	184,070	260,403 [r]	61,501 [r]	70,000
Turkey	3,515,644	3,995,423	3,449,773 [r]	4,322,543 [r]	4,000,000
Uganda, pozzolanic materials[e]	140,000	140,000	140,000	140,000	140,000

See footnotes at end of table.

TABLE 4—Continued

PUMICE AND RELATED MATERIALS: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
United States, pumice, sold and used by producers	1,540,000	1,270,000	791,000	410,000	390,000 [4]
Grand total	19,900,000 [r]	20,700,000	18,400,000 [r]	17,800,000 [r]	17,300,000
Of which:					
Pumice	2,860,000 [r]	2,950,000	2,560,000 [r]	1,720,000	1,710,000
Pozzolan	8,270,000	8,700,000	7,390,000 [r]	6,770,000 [r]	6,670,000
Trass and scoria	1,000	1,000	1,000	1,000	1,000
Volcanic tuff	885,000	1,060,000	1,220,000 [r]	1,300,000 [r]	1,300,000
Unspecified	7,910,000	7,990,000	7,230,000 [r]	7,970,000 [r]	7,640,000

[e] Estimated. [r] Revised. NA Not available. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 5, 2011.

[3] Pumice and related materials also are produced in a number of other countries, including China, Japan, Mexico, and the Commonwealth of Independent States, but available information is inadequate for the formulation of reliable estimates of output levels.

[4] Reported figure.

[5] Data are for year ending July 7 of that stated.

[6] On February 17, 2008, the Kosovo Assembly declared independence from Serbia. Kosovo's data for 1999–2007 are not included in Serbian statistics.

[7] Converted from reported data, in cubic meters, as follows: 2008—45,005 and 2009—58,788.

RARE EARTHS

By Joseph Gambogi and Daniel J. Cordier

Domestic survey data and tables were prepared by Martha L. Jackson, statistical assistant and the world production tables were prepared by Lisa D. Miller, international data coordinator.

In 2010, world rare-earth production was primarily from the mineral bastnäsite. Rare earths were not mined in the United States in 2010. Rare-earth ores were primarily mined in China, with smaller amounts mined in India, Malaysia, and Brazil, listed in order of decreasing production. Processing of intermediate rare-earth concentrates took place at the Mountain Pass Mine in California.

Domestic use of scandium remained small in 2010. Demand was primarily for aluminum alloys used in baseball and softball bats. Scandium alloys, compounds, and metals were used in analytical standards, metallurgical research, and sports equipment. Minor amounts of high-purity scandium were used in semiconductors and specialty lighting.

Based on import data from the Port Import Export Reporting Service (PIERS) database of Commonwealth Business Media, Inc. (undated), domestic yttrium consumption increased by 43% in 2010 compared with that of 2009. Yttrium was used primarily in linear fluorescent lamp and cathode-ray tube (CRT) phosphors; lesser amounts were used in structural ceramics and oxygen sensors.

The rare earths are a moderately abundant group of 17 elements comprising the 15 lanthanides, scandium, and yttrium. The elements range in crustal abundance from cerium, the 25th most abundant element of the 78 common elements in the Earth's crust at 60 parts per million (ppm), to thulium and lutetium, the least abundant rare-earth elements (REE), at about 0.5 ppm (Mason and Moore, 1982, p. 46). In rock-forming minerals, rare earths typically occur in compounds as trivalent cations in carbonates, oxides, phosphates, and silicates.

The lanthanides (also referred to as lanthanoids) comprise a group of 15 elements with atomic numbers 57 through 71 that include the following in order of atomic number: lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, and lutetium. At an average concentration in the Earth's crust of 60 ppm, cerium is more abundant than copper, followed in decreasing order, by yttrium at 33 ppm, lanthanum at 30 ppm, and neodymium at 28 ppm. Thulium and lutetium, the least abundant of the lanthanides at 0.5 ppm, occur in the Earth's crust in higher concentrations than antimony, bismuth, cadmium, and thallium.

Rare earths can be classified as either light rare-earth elements (LREE) or heavy rare-earth elements (HREE). This division between the LREE include the lanthanide elements from atomic number 57 (lanthanum) through atomic number 64 (gadolinium), and the HREE include the lanthanide elements from atomic number 65 (terbium) through atomic number 71 (lutetium). The division is based on the lanthanoid LREE having unpaired electrons in the 4f electron shell, and HREE having paired electrons in the 4f electron shell. Gadolinium has a very stable half-filled 4f electron shell with seven unpaired electrons. Proceeding with terbium and continuing along the series through lutetium, paired electrons are progressively added to the 4f electron shell for each respective element in the HREE lanthanoid series until there is a full complement of 14 electrons in the 4f electron shell of lutetium. The division between LREE and HREE lanthanoids falls between gadolinium and terbium. Yttrium is included as a HREE even though it is not part of the lanthanoid contraction series.

Scandium (atomic number 21), a transition metal, is the lightest REE but it is not classified as one of the group of LREE nor one of the HREE. It is the 31st most abundant element in the Earth's crust, with an average crustal abundance of 22 ppm. Scandium is a soft, lightweight, silvery-white metal, similar in appearance and weight to aluminum. It is represented by the chemical symbol Sc and has one naturally occurring isotope. Although its occurrence in crustal rocks is greater than that of lead, mercury, and the precious metals, scandium rarely occurs in concentrated quantities because it does not selectively combine with the common ore-forming anions.

Yttrium (atomic number 39), a transition metal, is chemically similar to the lanthanides and often occurs in the same minerals as a result of its similar ionic radius. Its atomic radius of 104 picometers in the trivalent state places it in relative size between the ionic radii of holmium and erbium (104.1 and 103, respectively). It is included as one of the HREE. It is represented by the chemical symbol Y and has one naturally occurring isotope. Yttrium is the second most abundant rare earth in the Earth's crust. Yttrium is a bright silvery metal that is soft and malleable, similar in density to titanium.

The elemental forms of rare earths are iron gray to silvery lustrous metals that are typically soft, malleable, ductile, and usually reactive, especially at elevated temperatures or when finely divided. Melting points range from 798° C for cerium to 1,663° C for lutetium. The unique properties of rare earths are used in a wide variety of applications. The principal economic ores of the rare earths are the minerals bastnäsite, loparite, and monazite and the lateritic ion-adsorption clays (table 2).

Production

In December 2010, Molycorp, Inc. resumed mining at its Mountain Pass operation and was preparing to resume milling operations. During 2010, Molycorp produced more than 3,000 metric tons (t) of rare-earth materials from stockpiled feedstock. A two-phase expansion plan was underway that would increase capacity to 19,100 metric tons per year (t/yr) of rare-earth oxides (REO) by yearend 2012 and 40,000 t/yr by yearend 2013. In July, Molycorp became a publicly traded company. Molycorp conducted additional drilling and exploration work in 2010 with a primary focus on in-fill drilling. The company planned additional drilling and exploration work in 2011. Proven reserves at Mountain Pass were estimated to be about 40,000 t of REO and probable reserves to be about 962,000 t of REO (Molycorp, Inc., 2011, p. 35–39).

Two companies processed intermediate rare-earth compounds to lanthanides in 2010. Grace Davison (a subsidiary of W.R. Grace & Co.) processed intermediate rare-earth compounds to produce cerium- and lanthanum-rich compounds used in making fluid-cracking catalysts for the petroleum refining industry. The company also processed zirconia-stabilized ceria compounds for supports for automotive catalysts, fluid catalytic cracking additives, and oxidation of organic compounds in wastewater, and produced several grades of Vitrox and Rareox cerium oxide polishing compounds.

In April, Molycorp acquired Santoku America, Inc. (Molycorp, Inc., 2011, p. 7). Santoku America produced rare-earth metals and magnet alloys at its operations in Tolleson, AZ. Santoku America produced two types of alloys used in high-strength permanent magnets—neodymium-iron-boron (NIB) and samarium-cobalt (SmCo)—and was the sole domestic producer of NIB magnet alloys. The plant also produced a full range of high-purity rare-earth metals, including scandium and yttrium, in cast and distilled forms, as foils, and as sputtering targets.

The only U.S. producer of rare-earth permanent magnets was Electron Energy Corp. (EEC) of Landisville, PA. EEC produced SmCo permanent magnets and designed and manufactured magnet assemblies, including actuators, Halbach arrays (magnetic field focusing assemblies), high-speed rotors, and other components.

One U.S. scandium processor operated in 2010. Sigma-Aldrich Co. LLC in Urbana, IL, purified and processed imported oxides to produce high-purity scandium compounds, including anhydrous and hydrous chloride, fluoride, iodide, and oxide. The company also produced high-purity scandium metal. High-purity products were available in various grades, with scandium oxide having up to 99.999% purity.

Boulder Scientific Co., another processor, had scandium facilities on standby at its Mead, CO, operation. Boulder Scientific previously refined scandium primarily from imported oxides and domestic ores to produce high-purity scandium compounds, including carbide, chloride, diboride, fluoride, hydride, nitride, oxalate, and tungstate.

All domestic, commercially produced, purified yttrium products were derived from imported compounds. The principal source was China.

Owing to market conditions, several mineral exploration and development projects were underway. Drilling and prefeasibility studies were underway in Alaska, Nebraska, and Wyoming.

In May, Rare Element Resources Ltd. increased the resource estimate for its Bear Lodge project in Wyoming by 50%. The new resource estimate for REO contained in the Bull Hill area of the project was 549,000 t with a 1.5% REO cutoff grade (Rare Element Resources Ltd., 2010b). In November, the company completed a scoping study on its Bear Lodge project. Based on the results of the scoping study, the company planned to begin prefeasibility studies to update the mineral resource estimate and begin more detailed metallurgical testing and engineering studies in 2011 (Rare Element Resources Ltd., 2010a).

Quantum Rare Earth Developments Corp. acquired the Elk Creek niobium-rare earth project in southeastern Nebraska. The Elk Creek property contains an intrusive carbonatite complex containing niobium and rare-earth elements. In 2010, Quantum began an exploration program of the property including a review of the historic exploration of the property during the 1970s and 1980s (Quantum Rare Earth Developments Corp., 2010).

In Alaska, Ucore Rare Metals Inc. conducted a drilling program at its Bokan Mountain-Dodson property to confirm previous drilling results and to examine mineralization at greater depth. A National Instrument (NI) 43–101-compliant resource estimate was expected to be completed in 2011 (Ucore Rare Metals Inc., 2010).

Consumption

Data on domestic rare-earth consumption were developed by surveying various processors and manufacturers and evaluating import and export data. Domestic apparent consumption of rare earths was not calculated in 2010 because data were withheld to avoid disclosing company proprietary data.

In 2010, yttrium consumption was estimated to have increased to 670 t from 468 t in 2009. Yttrium information was based on data retrieved from the PIERS database. The leading source of yttrium compounds and metal in 2010 was China (84%). The estimated use of yttrium, based on imports, was primarily in fluorescent lamp and CRT phosphors, ceramics, and specialty alloys, with a minor amount for metal casting.

Prices

China's actions to restrict exports of REO through quotas and taxes caused prices of rare-earth products to rise significantly. The prices of most rare-earth materials, provided by Rhodia Inc., were higher or the same in 2010 compared with those of 2009 (table 3). On average, REO prices increased by 29% from those in 2009. Scandium oxide prices were slightly higher than those in 2009.

The average yearend rare-earth metal prices from Metal-Pages Ltd. increased more than 200% in 2010 compared with those in 2009. Lanthanum metal (used in nickel-metal hydride batteries) and cerium metal (used in mischmetal and in iron and steelmaking) increased by more than five times to $60.50 and $51.50 per kilogram. Prices for neodymium ($114 per kilogram) and dysprosium ($400 per kilogram), used in permanent magnets, increased by 285% and 171%, respectively, compared with those in 2009.

Prices for scandium metal in ingot form were unchanged at $158,000 per kilogram.

Foreign Trade

Data in this section are based on gross weight, although data in the tables are also converted to REO content. U.S. exports totaled 8,090 t valued at $88 million, an 8% increase in quantity and a 52% increase in value compared with those of 2009. On a gross-weight basis, ferrocerium was the largest export category, accounting for 48% of the total exports (table 4).

U.S. rare earth imports totaled 16,200 t valued at $189 million, approximately an 8% increase in quantity and a 67% increase in value compared with those of 2009. China dominated the import market, especially for mixed and individual rare-earth compounds, except for the category of ferrocerium and other pyrophoric alloys, where France dominated. In decreasing order of import quantity, the leading supply countries were China, France, and Japan. These three countries accounted for 94% of the domestic imports.

World Review

Australia.—In New South Wales, Alkane Resources Ltd. continued to develop its Dubbo Zirconia project with planned production of hafnium, niobium, rare earths, tantalum, and zirconium products. In 2010, Alkane Resources continued to optimize separation technologies using a demonstration pilot plant at ANSTO Minerals laboratories near Sydney. A definitive feasibility study based on a potential production of 4,610 t/yr of rare-earth oxides was underway. At yearend, measured resources of REO were 54.9 million metric tons. Production was not expected to begin until 2014 (Alkane Resources Ltd., 2011).

Aurafura Resources Ltd. continued to develop its Nolans Bore mining and beneficiation project in the Northern Territory and its Whayalla processing operation in South Australia. In 2010, Aurafura began a bankable feasibility study and conducted environment and technology demonstration studies for the mine and processing operations. The bankable feasibility study was expected to be completed in 2011, and initial production targeted for 2013. The Whyalla operation was expected to reach full production of 20,000 t/yr of REO by 2014 (Ward, 2010, p. 17).

In Western Australia, engineering and construction of a mineral concentration plant at Lynas Corp. Ltd.'s Mount Weld deposit was 80% complete, and an 18-month stockpile of crushed ore to feed the plant was in place at yearend. Production of concentrate for Lynas Corp.'s Malaysian REO processing operation was scheduled to begin in 2011 (Lynas Corp. Ltd., 2011, p. 2).

Canada.—In the Northwest Territories, Avalon Rare Metals Inc. completed a prefeasibility study on its Thor Lake (Nechalco) project in June. The study was based on an initial production output of 5,000 t/yr of REO and probable mineral reserves of 204,000 t REO (Avalon Rare Metals Inc., 2010b). In September, Avalon announced it had completed a NI 43–101 resource update on the Nechalco deposit. The indicated resource was 359,000 t of REO (Avalon Rare Metals Inc., 2010a).

In Quebec, Matamec Explorations Inc. continued drilling its Kipawa deposit and had SGS Geostat Inc. complete a NI 43-101 resource estimate. The resource was considered under two scenarios—as a resource of rare earths and yttrium with zirconium as a byproduct, and as a resource of zirconium with rare earths and yttrium as a byproduct. SGS Geostat estimated that the indicated resources included up to 30,200 t of REO. In September, Matamec announced that it had contracted Roche Ltd. to assist in the development of NI 43–101-compliant preliminary economic assessment (Matamec Explorations Inc., 2011, p. 11–14).

In Quebec and Newfoundland and Labrador, Quest Rare Minerals Ltd. continued exploration drilling and completed preliminary resource and economic assessments on its Strange Lake property in September. From the assessments, the company determined that the deposit warranted further investigation and development. The operation could produce more than 22,600 t/yr of REO concentrate. Feasibility studies were scheduled to begin in 2011 (Quest Rare Minerals Ltd., 2010).

China.—China continued to dominate the supply of REE, accounting for 97% of global mine production. Mine production was primarily from bastnäsite and other rare-earth minerals in Inner Mongolia-Autonomous Region and Sichuan Province and from ion adsorption ore in the southeastern Provinces of Fujian, Guangdong, and Jiangxi (Grauch and Mariano, 2008).

Citing domestic requirements and environmental concerns, China restricted supply of REE through export quotas and taxes. China's Ministry of Land and Resources set a production quota for rare-earth concentrate at 89,200 t of contained REO. According to figures from the China Rare Earth Society, however, production was actually about 130,000 t (Reuters, 2011). The Ministry of Industry and Information Technology announced that the 2011 production quota for rare-earth separated products would be 90,400 t. Provincial governments were responsible for managing their allocated quotas and assigning the output quota to individual mining companies (Ministry of Industry and Information Technology of the People's Republic of China, 2010).

The Ministry of Finance and the Administration of Taxation announced that the resource tax on bastnasite and monazite would be taxed at 60 yuan per metric ton and that middle and heavy rare earths would be taxed at a rate of 30 yuan per metric ton beginning on April 1, 2011 (Ministry of Finance of the People's Republic of China, 2010, p. 301).

The autonomous government of Inner Mongolia granted Baotou Rare Earth Co. (Baotou), China's leading REO producer, authority to build a stockpile of rare-earth products and to build facilities to store 200,000 t of REO. In 2009, Baotou REO production was estimated to be about 55,000 t, but the regional government limited the company's sales to 50,000 t in 2010. Any production in 2010 beyond the 50,000 t limit was assumed to be incorporated into the stockpile (Reuters, 2010). Baotou moved to expand its rare-earth interest in southern China by investing 232 million yuan ($34.3 million) in three REE companies in Jiangxi Province. In August, Baotou announced plans to acquire 48% interest in Xinfeng Xinli Rare Earths Co., Ltd., 49% interest in a joint venture with Quannan Jinghuan Technology Co., Ltd., and 9.25% interest in Ganzhou Chenguang Rare Earths Co., Ltd. (China Daily, 2010).

Estonia.—Molycorp acquired a 90% interest in Aktsiaselts Silmet, one of two rare-earth processing facilities in Europe. The acquisition doubled Molycorp's REO production capacity to 6,000 t/yr and gave the company the ability to produce didymium metal (Molycorp, Inc., 2011, p. 7).

India.—Toyota Tsusho Corp. and its Indian subsidiary (Toyotsu Rare Earths Orissa Pvt. Ltd.) were promoting a plan to construct a REO processing plant in Orissa. The plan called for 3,000 to 4,000 t/yr of REO derived from monazite produced at Indian Rare Earth Ltd.'s heavy-mineral sands operation. In October, Government officials from India and Japan agreed to collaborate on the development and reuse of rare-earth materials (Toyota Tsusho Corp., 2010).

Japan.—Japan Oil, Gas and Metals National Corp. (JOGMEC) entered into an agreement with Midland Exploration Inc. for rare-earths development near the Quest Rare Minerals Ltd.'s Strange Lake project in the Ytterby region of Canada. Under the agreement, JOGMEC would earn a 50% interest in the project by spending CAD$2.7 million during 3 years. JOGMEC could take products in proportion to the interest and have the right of first refusal on the other party's share of the products (Japan Oil, Gas and Metals National Corp., 2010).

Malaysia.—Lynas Corp. neared completion of its advanced materials processing plant near Kuantan with an initial capacity of 11,000 t/yr of REO. A second phase of construction was scheduled to be completed in 2012 that would double REO production capacity (Lynas Corp. Ltd., 2011, p. 2).

South Africa.— Great Western Minerals Group Ltd. (GWMG) was moving ahead with a project to recommission the abandoned Steenkampskraal mine in the Western Cape owned by Steenkampskraal Monazite Mine Ltd. In June, GWMG appointed SRK Engineers and Scientists of Johannesburg to complete a feasibility study on the project and, in August, agreed to purchase all of the rare-earth materials produced by the mine for a 10-year period. At yearend, GWMG held interest in the Steenkampskraal mine and in six REE properties in North America (Great Western Minerals Group Ltd., 2011).

United Kingdom.—GWMG planned to increase rare-earth metals processing capacity at its subsidiary, Less Common Metals Ltd. (LCM). A new furnace at its Hooton Park operation, Birkenhead, was expected to increase LCM's processing capacity by approximately 50%, and was scheduled to be in production by the third quarter of 2011. The new furnace was designed to provide NdFeB alloys for sintered magnets (Great Western Minerals Group Ltd., 2010).

Vietnam.—The Dong Pao Mine in the northern part of Vietnam has large resources of rare earths. The ownership included six Vietnamese companies. VIMICO (Vietnam National Minerals) and VINACOMIN (Vietnam National Coal-Mineral Industries Group) jointly held 55% of the shares. The mining rights were owned by LARESCO and Lai Chau Rare Earth in a joint venture. Two other Japanese companies—Toyota Tsusho and Sojitz—also held an interest in the Dong Pao Mine (Roskill's Letters from Japan, 2010).

Outlook

Rare-earth use in automotive pollution control catalysts, permanent magnets, and rechargeable batteries is expected to continue to rise as future global demand for conventional and hybrid automobiles, computers, electronics, and portable equipment increases. Rare-earth markets are expected to require greater amounts of higher purity mixed and separated products to meet the demand. Demand for cerium and neodymium for use in automotive catalytic converters and catalysts for petroleum refining is expected to trend with refinery and automotive production. REE magnet production was projected to increase to 150,000 t by 2014 from 92,000 t in 2011. Future growth was expected for rare earths in rechargeable NiMH batteries, especially those used in hybrid vehicles, increasing to 62,000 t REO by 2014 (BCC Research, 2010). NiMH demand was also expected to increase (moderated by increasing demand for lithium-ion batteries), with increased use in portable electronic equipment. Increased rare-earth use was expected in fiber optics, medical applications that include dental and surgical lasers, magnetic resonance imaging, medical contrast agents, medical isotopes, and positron emission tomography scintillation detectors.

Although the rare earth content of world reserves is greater than cumulative world consumption expected well into the 21st century, current annual production is less than current world consumption; there are shortages for neodymium and dysprosium for magnet alloys and europium and terbium for phosphors. Companies are working to develop rare-earth deposits in Australia, Canada, Greenland, South Africa, and the United States.

All domestic and most foreign companies have currently shifted away from using naturally occurring radioactive rare-earth ores. This trend has had a negative impact on monazite-containing mineral sands operations worldwide, causing mine closures and reduced revenues. Long-term demand for monazite, however, is expected to increase because of the mineral's abundant supply and low-cost byproduct recovery. Thorium's use as a nonproliferative nuclear fuel is considered a likely substitute for uranium in the future. If consumption of thorium increases, monazite could resume its role as a major source of rare earths. Storage requirements and permits to dispose of radioactive waste products in the United States are expensive; however, severely limiting domestic use of low-cost monazite and other thorium-bearing rare-earth ores.

China was expected to remain a major world rare-earth supplier. Increasing prices, export limits, rising demand within China, and a ban on new mining permits in China were expected to make rare-earth deposits outside of China more economic. Economic growth in several developing countries could provide new and potentially large markets for rare earths in eastern Europe, India, and southeastern Asia.

The long-term outlook appears to be for an increasingly competitive and diverse group of rare-earth suppliers. As research and technology continue to advance the knowledge of rare earths and their interactions with other elements, the economic base of the rare-earth industry is expected to continue to increase. New applications are expected to continue to be discovered and developed, especially in areas that are considered essential, such as energy and defense.

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TABLE 1

SALIENT U.S. RARE EARTH STATISTICS[1]

		2006	2007	2008	2009	2010
Production of rare-earth concentrates, rare-earth oxide (REO) basis[e]	metric tons	--	--	--	--	--
Exports, REO basis:						
Cerium compounds	do.	2,010	1,470	1,380	840	1,350
Ferrocerium and pyrophoric alloys	do.	3,710	3,210	4,490	2,970	3,460
Rare-earth compounds, organic or inorganic	do.	2,700	1,300	663	455	1,690
Rare-earth metals, scandium, yttrium	do.	611	1,470	1,390	4,930	1,380
Imports for consumption, REO basis:[e]						
Cerium compounds	do.	2,590	2,680	2,080	1,500	1,770
Ferrocerium and pyrophoric alloys	do.	127	123	125	102	131
Mixtures of rare-earth chlorides except cerium chloride	do.	2,750	1,610	1,310	411	956
Mixtures of REOs except cerium oxide	do.	1,580	2,570	2,400	4,750	5,480
Rare-earth compounds, oxides, hydroxides, nitrates, other compounds except chlorides	do.	10,600	9,900	8,820	5,080 [r]	3,980
Rare-earth metals, whether intermixed or alloyed	do.	867	784	679	226	525
Yttrium compounds	do.	168	21	10	7	73
Prices, yearend:						
Bastnäsite concentrate, REO basis	dollars per kilogram	6.06	6.61	8.82 [r]	5.73 [r]	6.87
Monazite concentrate, REO basis	do.	0.73	0.73	0.48	0.87 [r]	0.87
Mischmetal, metal basis[2]	do.	5.00–6.00	7.00–8.00	8.00–9.00 [r]	8.00–9.00 [r]	45.00–55.00

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[e] Estimated. [r] Revised. do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Source: HEFA Rare Earths Canada Co. Ltd., Vancouver, British Columbia, Canada.

TABLE 2

RARE EARTH CONTENTS OF MAJOR AND POTENTIAL SOURCE MINERALS[1, 2]

(Percentage of total rare-earth oxide)

	Bastnäsite		Monazite			
Rare earth	Mountain Pass, CA, United States[3]	Bayan Obo, Inner Mongolia, China[4]	North Capel, Western Australia[5]	North Stradbroke Island, Queensland, Australia[6]	Green Cove Springs, FL, United States[7]	Nangang, Guangdong, China[8]
Yttrium	0.10	trace	2.40	2.50	3.20	2.40
Lanthanum	33.20	23.00	23.90	21.50	17.50	23.00
Cerium	49.10	50.00	46.00	45.80	43.70	42.70
Praseodymium	4.34	6.20	5.00	5.30	5.00	4.10
Neodymium	12.00	18.50	17.40	18.60	17.50	17.00
Samarium	0.8	0.8	2.53	3.10	4.90	3.00
Europium	0.1	0.2	0.053	0.8	0.16	0.1
Gadolinium	0.2	0.7	1.49	1.80	6.60	2.00
Terbium	trace	0.1	0.035	0.3	0.26	0.7
Dysprosium	trace	0.1	0.7	0.60	0.9	0.8
Holmium	trace	trace	0.053	0.1	0.11	0.12
Erbium	trace	trace	0.2	0.2	trace	0.3
Thulium	trace	trace	trace	trace	trace	trace
Ytterbium	trace	trace	0.1	0.1	0.21	2.40
Lutetium	trace	trace	trace	0.01	trace	0.14
Total	100	100	100	100	100	100

	Monazite—Continued		Xenotime		Rare earth laterite	
	Eastern coast, Brazil[9]	Mount Weld, Australia[10]	Lahat, Perak, Malaysia[3]	Southeast, Guangdong Province, China[11]	Xunwu, Jiangxi Province, China[12]	Longnan, Jiangxi Province, China[12]
Yttrium	1.40	trace	61.00	59.30	8.00	65.00
Lanthanum	24.00	26.00	1.24	1.20	43.4	1.82
Cerium	47.00	51.00	3.13	3.00	2.40	0.4
Praseodymium	4.50	4.00	0.5	0.6	9.00	0.7
Neodymium	18.50	15.00	1.60	3.50	31.70	3.00
Samarium	3.00	1.80	1.10	2.20	3.90	2.80
Europium	0.1	0.4	trace	0.2	0.5	0.10
Gadolinium	1.00	1.00	3.50	5.00	3.00	6.90
Terbium	0.1	0.1	0.9	1.20	trace	1.30
Dysprosium	0.4	0.2	8.30	9.10	trace	6.70
Holmium	trace	0.1	2.00	2.60	trace	1.60
Erbium	0.1	0.2	6.40	5.60	trace	4.90
Thulium	trace	trace	1.10	1.30	trace	0.7
Ytterbium	0.02	0.1	6.80	6.00	0.3	2.50
Lutetium	not determined	trace	1.00	1.80	0.1	0.4
Total	100	100	100	100	100	100

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Rare earths are listed in order of atomic number.

[3] Johnson, G.W., and Sisneros, T.E., 1981, Analysis of rare-earth elements in ore concentrate samples using direct current plasma spectrometry—Proceedings of the 15th Rare Earth Research Conference, Rolla, MO, June 15–18, 1981: New York, NY, Plenum Press, v. 3, p. 525–529.

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[5] Westralian Sands Ltd., 1979, Product specifications, effective January 1980: Capel, Australia, Westralian Sands Ltd. brochure, 8 p.

[6] Analysis from Consolidated Rutile Ltd.

[7] Analysis from RGC Minerals (USA), Green Cove Springs, FL.

[8] Xi, Zhang, 1986, The present status of Nd-Fe-B magnets in China—Proceedings of the Impact of Neodymium-Iron-Boron Materials on Permanent Magnet Users and Producers Conference, Clearwater, FL, March 2–4, 1986: Clearwater, FL, Gorham International Inc., 5 p.

[9] Krumholz, Pavel, 1991, Brazilian practice for monazite treatment: Symposium on Rare Metals, Sendai, Japan, December 12–13, 1991, Proceedings, p. 78–82.

TABLE 2—Continued

RARE EARTH CONTENTS OF MAJOR AND POTENTIAL SOURCE MINERALS[1, 2]

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[10] Kingsnorth, Dudley, 1992, Mount Weld—A new source of light rare earths—Proceedings of the TMS and Australasian Institute of Mining and Metallurgy Rare Earth Symposium, San Diego, CA, March 1–5, 1992: Sydney, Australia, Lynas Gold NL, 8 p.

[11] Nakamura, Shigeo, 1988, China and rare metals—Rare earth: Industrial Rare Metals, no. 94, May, p. 23–28.

[12] Jiangxi Province, 1985, Introduction to Jiangxi rare-earths and applied products: Jiangxi Province, China, Jiangxi Province brochure, 42 p.

TABLE 3

RARE-EARTH OXIDE PRICES IN 2010[e, 1]

Product (oxide)	Purity (percentage)	Standard package quantity (kilograms)	Price (dollars per kilogram)
Scandium	99.99	NA	3,500.00
Yttrium	99.99	20	50.00
Lanthanum	99.99	20	38.00
Cerium	96.00	20	30.00
Do.	99.50	20	NA
Praseodymium	96.00	20	60.00
Neodymium	95.00	20	63.00
Samarium	99.90	20	175.00
Do.	99.99	20	NA
Europium	99.99	20	1,400.00
Gadolinium	99.99	20	165.00
Terbium	99.99	20	1,400.00
Dysprosium	99.00	20	310.00
Holmium	99.90	10	750.00
Erbium	96.00	20	165.00
Thulium	99.90	5	1,500.00
Ytterbium	99.00	10	375.00
Lutetium	99.99	1 or 10	2,200.00

[e] Estimated. Do. Ditto. NA Not available.

[1] Rare earths are listed in order of atomic number.

Source: Rhodia, Inc.

TABLE 4

U.S. EXPORTS OF RARE EARTHS, BY COUNTRY[1]

	2009		2010	
Category[2] and country	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Cerium compounds (2846.10.0000):				
Australia	1,920	$13,300	9	$8,060
Austria	43,800	437,000	122,000	1,530,000
Belgium	1,800	21,800	5,000	5,000
Brazil	11,400	95,900	7,900	133,000
Canada	15,300	151,000	25,300	284,000
China	72,800	878,000	255,000	2,110,000
France	3,950	47,200	95,300	412,000
Germany	94,800	731,000	124,000	1,110,000
Hong Kong	3,930	128,000	18,100	446,000
India	60,600	402,000	15,700	159,000
Japan	114,000	1,320,000	180,000	3,170,000
Korea, Republic of	15,800	79,400	25,900	214,000
Mexico	192,000	800,000	241,000	1,420,000
Netherlands	43,300	241,000	64,500	364,000
Singapore	10,100	64,600	181	9,500
Taiwan	7,340	96,700	8,490	156,000
United Kingdom	14,200	99,500	14,400	737,000
Other	133,000	2,430,000	151,000	2,080,000
Total	840,000	8,030,000	1,350,000	14,300,000
Total estimated equivalent rare-earth oxide (REO) content	840,000	XX	1,350,000	XX
Ferrocerium and other pyrophoric alloys (3606.90.0000):				
Argentina	29,100	162,000	143	4,920
Australia	19,100	984,000	12,700	2,750,000
Canada	494,000	1,620,000	513,000	2,040,000
China	169,000	1,960,000	100,000	789,000
Egypt	451	77,700	1,260	102,000
France	66,300	1,170,000	35,400	183,000
Germany	342	14,200	7,760	176,000
Greece	888	274,000	639	42,200
Hong Kong	26,100	306,000	9,450	305,000
Israel	75	3,230	1,210	10,700
Japan	17,200	461,000	17,100	504,000
Korea, Republic of	4,240	255,000	1,380	73,100
Mexico	1,890,000	4,200,000	2,300,000	4,840,000
Netherlands	33,100	171,000	229,000	1,180,000
New Zealand	--	--	16,700	55,600
Saudi Arabia	1,020	33,700	268	5,400
Singapore	477	14,500	1,280	40,300
Taiwan	164	5,970	408	13,200
United Arab Emirates	1,680	32,100	--	--
United Kingdom	296,000	14,000,000	168,000	4,790,000
Other	299,000	2,290,000	478,000	1,120,000
Total	3,350,000	28,000,000	3,900,000	19,000,000
Total estimated equivalent REO content	2,970,000	XX	3,460,000	XX

See footnotes at end of table.

TABLE 4—Continued

U.S. EXPORTS OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2009		2010	
	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Rare-earth compounds[3] (2846.90.0000):				
Austria	491	$3,470	279,000	$616,000
Brazil	13,400	122,000	9,450	248,000
Canada	53,900	479,000	49,600	588,000
China	43,200	488,000	47,000	906,000
Colombia	1,640	$29,200	9,010	$25,500
Congo (Brazzaville)	--	--	69,900	437,000
Estonia	--	--	77,700	220,000
France	28,500	543,000	23,000	442,000
Germany	18,200	502,000	38,200	1,420,000
Hong Kong	2,050	125,000	1,090	69,500
India	4,190	49,600	18,500	127,000
Italy	8,110	89,700	16,300	108,000
Japan	63,900	1,870,000	379,000	13,900,000
Korea, Republic of	74,000	405,000	90,100	940,000
Mexico	43,900	502,000	79,800	1,160,000
Netherlands	9,370	44,400	107,000	1,560,000
Singapore	6,190	94,500	12,000	204,000
Spain	16	22,000	141,000	187,000
Taiwan	1,810	46,800	1,670	407,000
United Kingdom	3,620	229,000	77,400	1,930,000
Vietnam	2,800	31,100	62,500	682,000
Other	75,700 [r]	542,000 [r]	103,000	1,060,000
Total	455,000	6,210,000	1,690,000	27,200,000
Total estimated equivalent REO content	455,000	XX	1,690,000	XX
Rare-earth metals, including scandium and yttrium (2805.30.0000):				
Belgium	268	24,600	8	39,700
Brazil	16,800	221,000	84,200	1,290,000
China	365,000	1,370,000	316,000	1,230,000
Germany	4,800	232,000	7,220	317,000
Hong Kong	62,800	283,000	990	190,000
India	3,130	228,000	6,780	380,000
Japan	303,000	5,330,000	639,000	19,800,000
Mexico	150	80,800	675	83,700
Switzerland	48	28,400	1	3,260
Taiwan	1,190	46,600	801	64,700
Turkey	3,190,000	6,220,000	--	--
Other	157,000 [r]	1,650,000 [r]	93,300	4,110,000
Total	4,100,000	15,700,000	1,150,000	27,500,000
Total estimated equivalent REO content	4,920,000	XX	1,380,000	XX

[r] Revised. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States category numbers.

[3] Inorganic and organic.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2009		2010	
	Gross weight (kilograms)	Value	Gross weight (kilograms)	Value
Cerium compounds, including oxides, hydroxides, nitrates, sulfate, chlorides, oxalates (2846.10.0000):				
Austria	386,000	$1,140,000	131,000	$1,400,000
China	1,720,000	5,030,000	2,010,000	13,500,000
France	17,700	208,000	11,800	685,000
Japan	51,600	1,800,000	139,000	4,700,000
Korea, Republic of	--	--	32,400	275,000
United Kingdom	17,300	68,100	60,100	155,000
Other	49,200	812,000	262,000	1,980,000
Total	2,240,000	9,070,000	2,640,000	22,600,000
Total estimated equivalent rare-earth oxide (REO) content	1,500,000	XX	1,770,000	XX
Ferrocerium and other pyrophoric alloys (3606.90.3000):				
Austria	21,000	457,000	25,400	626,000
China	4,280	90,300	11,900	184,000
France	89,100	2,080,000	110,000	2,290,000
Taiwan	--	--	700	9,530
Total	114,000	2,620,000	148,000	3,110,000
Total estimated equivalent REO content	102,000	XX	131,000	XX
Mixtures of rare-earth chlorides, except cerium chloride (2846.90.2050):				
Australia	--	--	1,930	3,190
Canada	617	2,570	--	--
China	887,000	4,560,000	2,030,000	11,100,000
Estonia	--	--	4,000	126,000
France	21	9,940	10,300	243,000
Germany	129	112,000	336	87,000
Japan	5,550	108,000	19,500	206,000
Russia	59	127,000	138	76,400
United Kingdom	787	10,700	15,000	121,000
Total	894,000	4,930,000	2,080,000	12,000,000
Total estimated equivalent REO content	411,000	XX	956,000	XX
Mixtures of REOs except cerium oxide (2846.90.2010):				
China	4,700,000	19,100,000	5,410,000	33,400,000
France	--	--	56	22,900
Germany	934	108,000	1,270	65,400
Ireland	--	--	34,600	2,830,000
Italy	42,500	4,190,000	18,400	1,790,000
Japan	6,130	64,900	9,310	148,000
Russia	111	66,900	63	35,100
Total	4,750,000	23,500,000	5,480,000	38,300,000
Total estimated equivalent REO content	4,750,000	XX	5,480,000	XX
Rare-earth compounds, including oxides, hydroxides, nitrates, other compounds except chlorides (2846.90.8000):				
Austria	58,200	2,650,000	108,000	4,390,000
Canada	3,000	15,000	--	--
China	5,590,000	38,600,000	4,080,000	55,400,000
France	331,000	13,000,000	542,000	16,600,000
Germany	35,300	304,000	700	208,000

See footnotes at end of table.

TABLE 5—Continued

U.S. IMPORTS FOR CONSUMPTION OF RARE EARTHS, BY COUNTRY[1]

Category[2] and country	2009 Gross weight (kilograms)	2009 Value	2010 Gross weight (kilograms)	2010 Value
Rare-earth compounds, including oxides, hydroxides, nitrates, other compounds except chlorides (2846.90.8000)—Continued:				
Hong Kong	600	$5,990	100	$6,800
Japan	143,000	9,350,000	417,000	17,300,000
Russia	109	95,300	13,200	339,000
South Africa	39,600	426,000	64,100	781,000
United Kingdom	157	49,000	43,800	211,000
Other	565,000	3,060,000	45,800	1,080,000
Total	6,770,000	67,500,000	5,310,000	96,300,000
Total estimated equivalent REO content	5,080,000 [r]	XX	3,980,000	XX
Rare-earth metals, whether intermixed or alloyed (2805.30.0000):				
Austria	227	36,100	3,610	223,000
Canada	--	--	224	19,700
China	167,000	3,790,000	361,000	12,300,000
Germany	--	--	70	17,600
Hong Kong	--	--	46,400	409,000
India	50	4,000	--	--
Japan	10,800	481,000	13,600	954,000
Korea, Republic of	--	--	53	51,600
Russia	2,110	182,000	3,620	328,000
Spain	31	2,450	--	--
United Kingdom	7,870	368,000	8,480	413,000
Vietnam	--	--	219	4,150
Total	188,000	4,870,000	437,000	14,700,000
Total estimated equivalent REO content	226,000	XX	525,000	XX
Yttrium compounds content by weight greater than 19% but less than 85% oxide equivalent (2846.90.4000):				
China	8,690	136,000	98,000	586,000
France	945	29,800	9,100	589,000
Japan	1,710	362,000	5,100	641,000
Other	190	37,500	10,200	243,000
Total	11,500	565,000	122,000	2,060,000
Total estimated equivalent REO content	6,920	XX	73,500	XX

[r] Revised. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States category numbers.

Source: U.S. Census Bureau.

TABLE 6

RARE EARTHS: ESTIMATED WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons of rare earth oxide equivalent)

Country[3]	2006	2007	2008	2009	2010
Brazil	527 [4]	645 [4]	460 [r, 4]	170 [r]	140
China	133,000	120,000	125,000	129,000	120,000
India	2,700	2,700	2,700	2,700	2,800
Kyrgyzstan	NA	NA	NA	NA	NA
Malaysia	430	380	120 [r]	13 [r]	400
Total	137,000	124,000	128,000	132,000	123,000

[r] Revised. NA Not available.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through October 4, 2011.

[3] In addition to the countries listed, rare-earth minerals are thought to be produced in some Commonwealth of Independent States countries besides Kyrgyzstan and in Indonesia, Nigeria, North Korea, and Vietnam, but information is inadequate for formulation of reliable estimates of output levels.

[4] Reported figure.

TABLE 7

MONAZITE CONCENTRATE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	2006	2007	2008	2009	2010
Brazil	958 [4]	1,173 [4]	1,200	1,200	1,200
India	5,000	5,000	5,000	5,000	5,000
Malaysia	894 [4]	682 [4]	233 [r]	25 [r]	30
Total	6,850	6,860	6,430 [r]	6,230 [r]	6,230

[r] Revised.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 9, 2011.

[3] In addition to the countries listed, China, Indonesia, Nigeria, North Korea, the Republic of Korea, and countries of the Commonwealth of Independent States may produce monazite, available information is inadequate for formulation of reliable estimates of ouput levels.

[4] Reported figure.

RECYCLING—METALS

By John F. Papp

Survey data and tables were prepared by Maria Arguelles, E. Lee Bray, James F. Carlin, Jr., Daniel L. Edelstein, Michael D. Fenton, Joseph Gambogi, David E. Guberman, Deborah A. Kramer, Peter H. Kuck, and Amy C. Tolcin.

In 2010, the United States recycled 66 million metric tons (Mt) of selected metals, an amount equivalent to 65% of the apparent supply of those metals (table 1). More than 90% of recycled metal was steel, and almost 90% of apparent supply was steel. The United States exported 26.4 Mt of scrap metal and imported 5.6 Mt of these same metals (table 2).

Metals are important, reusable resources. Although the ultimate supply of metal is fixed by nature, human ingenuity determines the quantity of supply available for use by developing economical processes to recover metal from the Earth (the primary source of metal) and recycle metal from the use/process stream (the secondary source of metal). The reusable nature of metals contributes to the sustainability of their use. Recycling, a significant factor in the supply of many of the metals used by our society, provides environmental benefits such as energy savings and reduced volumes of waste.

The term "primary" indicates material from ore deposits, and the term "secondary" indicates material from recycling, including used products and residuals from manufacturing. Recycling practices and the description of those practices vary substantially among the metal industries. Generally, scrap is categorized as "new" or "old." "New" indicates preconsumer sources, and "old," postconsumer sources. The many stages of industrial processing that precede formation of an end product are the sources of new scrap. For example, when metal is converted into shapes—bars, plates, rods, or sheets—new scrap is generated in the form of cuttings, trimmings, and off-specification forms. When these shapes are converted to parts, additional new scrap may be generated in the form of cuttings, stampings, turnings, and off-specification parts. Similarly, when parts are assembled into products, new scrap may be generated.

Once a product completes its useful life, it becomes old scrap. Used appliances, automobiles, and beverage cans are examples of old consumer scrap; used jet engine blades and vanes, junked machinery and ships, and metal recovered from commercial buildings or industrial plants are examples of old industrial scrap. A wide variety of descriptive terms, including external scrap, home scrap, internal scrap, mill scrap, prompt scrap, and purchased scrap, have evolved to describe scrap generated by diverse industry practices. The material flow of recycled metal commodities in the United States has been documented in a series of reports published by the U.S. Geological Survey (Sibley, 2006–11).

Individual annual reviews for each of the metals listed in the tables are in the respective chapters in this volume of the U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

Reference Cited

Sibley, S.F., ed., 2006–11, Flow studies for recycling metal commodities in the United States: U.S. Geological Survey Circular 1196–A–Z–AA, the 27 chapters are separately paginated and are available only at http://pubs.usgs.gov/circ/circ1196/. (Accessed May 29, 2012, via http://minerals.usgs.gov/minerals/pubs/commodity/recycle/.)

TABLE 1

SALIENT U.S. RECYCLING STATISTICS FOR SELECTED METALS[1]

	Quantity of metal (metric tons)					Value of metal (thousands)			
Year	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[5]	Percentage recycled[6]	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[7]
Aluminum:[8]									
2006 r	2,800,000	1,580,000	4,380,000	8,500,000	52	$7,490,000	$4,220,000	$11,700,000	$22,700,000
2007 r	2,450,000	1,660,000	4,120,000	7,320,000	56	6,610,000	4,480,000	11,100,000	19,700,000
2008 r	2,130,000	1,500,000	3,630,000	6,070,000	60	5,660,000	3,970,000	9,640,000	16,100,000
2009 r	1,570,000	1,260,000	2,820,000	4,890,000	58	2,740,000	2,200,000	4,940,000	8,550,000
2010	1,550,000	1,250,000	2,800,000	5,000,000	56	3,560,000	2,880,000	6,440,000	11,500,000
Chromium:[9]									
2006	NA	NA	179,000	432,000 r	41 r	NA	NA	213,000	1,870,000
2007	NA	NA	162,000	493,000	33	NA	NA	297,000	1,860,000
2008	NA	NA	146,000	432,000	34	NA	NA	491,000	2,600,000
2009	NA	NA	141,000	160,000	88	NA	NA	218,000 r	234,000 r
2010	NA	NA	144,000	383,000	38	NA	NA	171,000	883,000
Copper:[10]									
2006	819,000	150,000	968,000	3,010,000	32.1	5,680,000	1,040,000	6,720,000	20,900,000
2007	767,000	158,000	925,000	3,040,000	30.5	5,550,000	1,140,000	6,690,000	22,000,000
2008	697,000	156,000	852,000	2,690,000	31.7	4,900,000	1,100,000	6,000,000	18,900,000
2009	639,000 r	138,000 r	777,000 r	2,220,000 r	35.0	3,340,000 r	734,000 r	4,070,000 r	11,800,000
2010	639,000	131,000	770,000	2,380,000	32.4	4,930,000	1,010,000	5,940,000	18,300,000
Iron and steel:[11]									
2006	NA	NA	65,300,000	137,000,000	48	NA	NA	14,300,000	28,000,000
2007	NA	NA	64,000,000	119,000,000	54	NA	NA	16,200,000	29,200,000
2008	NA	NA	66,400,000	109,000,000	62	NA	NA	23,200,000	37,600,000
2009	NA	NA	53,200,000 r	69,300,000 r	77	NA	NA	11,000,000	12,600,000
2010	NA	NA	60,100,000	90,200,000	67	NA	NA	19,900,000	27,100,000
Lead:[12]									
2006	19,600	1,140,000	1,160,000	1,470,000	78.9	33,500	1,950,000	1,980,000	2,510,000
2007	24,100	1,160,000	1,180,000	1,540,000	76.7	65,700	3,150,000	3,220,000	4,200,000
2008	20,100	1,120,000	1,140,000	1,540,000	74.5	53,300	2,980,000	3,040,000	4,080,000
2009	21,600	1,090,000	1,110,000	1,380,000	80.5	41,400	2,090,000	2,130,000	2,640,000
2010	24,100	1,110,000	1,140,000	1,440,000	79.0	58,000	2,670,000	2,730,000	3,460,000
Magnesium:[13]									
2006	60,500	21,700	82,200	165,000	50	155,000	55,400	210,000	421,000
2007	59,900	23,500	83,300	160,000	52	227,000	89,000	316,000	608,000
2008	61,100	22,600	83,700	170,000	49	451,000	167,000	618,000	1,250,000
2009	47,100	20,500 r	67,600 r	118,000 r	58 r	269,000	117,000 r	386,000 r	672,000 r
2010	51,500	20,500	72,000	137,000	52	292,000	116,000	408,000	777,000
Nickel:[14]									
2006	NA	NA	104,000 r	247,000 r	42	NA	NA	2,510,000	5,990,000
2007	NA	NA	99,100 r	212,000 r	47	NA	NA	3,690,000 r	7,870,000
2008	NA	NA	85,300 r	200,000	43	NA	NA	1,800,000	4,230,000
2009	NA	NA	79,900	173,000	46	NA	NA	1,170,000	2,540,000 r
2010	NA	NA	106,000	219,000	49	NA	NA	2,320,000	4,760,000
Tin:[15]									
2006	2,340	11,600	13,900	51,600	27	29,100	145,000	174,000	642,000
2007	2,860	12,200	15,100	44,500	31	56,700	242,000	298,000	882,000
2008	2,100	11,700	13,800	24,700	56	52,300	291,000	344,000	615,000
2009	2,310	11,100	13,400	82,300	16	42,600	205,000	247,000	1,520,000
2010	2,680	10,900	13,600	42,600	32	73,200	298,000	371,000	1,160,000

See footnotes at end of table.

TABLE 1—Continued

SALIENT U.S. RECYCLING STATISTICS FOR SELECTED METALS[1]

Year	Quantity of metal (metric tons)					Value of metal (thousands)			
	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[5]	Percentage recycled[6]	Recycled from new scrap[2]	Recycled from old scrap[3]	Recycled[4]	Apparent supply[7]
Titanium:[16]									
2006	NA	NA	25,000	W	47	NA	NA	$253,000	NA
2007	NA	NA	23,800	W	41	NA	NA	167,000	NA
2008	NA	NA	23,200	W	W	NA	NA	148,000	NA
2009	24,700[e]	1,000[e]	25,700[e]	W	W	NA	NA	101,000	NA
2010	28,200	1,000[e]	29,200	W	46	NA	NA	212,000	NA
Zinc:[17]									
2006	294,000	47,900	342,000	1,530,000	22	$1,030,000	$168,000	1,200,000	$5,370,000
2007	207,000	26,700	234,000	1,270,000	18	705,000	90,900	796,000	4,340,000
2008	247,000	92,900	339,000	1,350,000	25	483,000	182,000	665,000	2,650,000
2009	194,000	78,900[r]	273,000	1,170,000	23	334,000	135,000	469,000	2,000,000
2010	208,000	123,000	331,000	1,240,000	27	468,000	276,000	744,000	2,780,000

[e]Estimated. [r]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Scrap that results from the manufacturing process, including metal and alloy production. New scrap of aluminum, copper, lead, tin, and zinc excludes home scrap, which is scrap generated and recycled in the metal producing plant.

[3] Scrap that results from consumer products.

[4] Metal recovered from new plus old scrap.

[5] Apparent supply is production plus net imports plus stock changes. Production is primary production plus recycled metal. Net imports are imports minus exports. Apparent supply is calculated on a contained-weight basis.

[6] Also referred to as recycling rate.

[7] Same as apparent supply defined in footnote 5 above but calculated based on a monetary value.

[8] Quantity of metal is the calculated metallic recovery from purchased new and old aluminum-base scrap, estimated for full industry coverage. Monetary value is estimated based on average U.S. market price for primary aluminum metal ingot. Series revised by removing imported scrap to avoid double counting.

[9] Chromium quantity of metal recycled was estimated as chromium content of stainless steel scrap receipts (reported by the iron and steel and pig iron industries). For the calculation of apparent supply, trade includes reported or estimated chromium content of chromite ore, ferrochromium, chromium metal and scrap, a variety of chromium-containing chemicals, and stainless steel mill products and scrap. Stocks include estimated chromium content of reported and estimated producer, consumer and Government stocks. Recycled monetary value estimated as recycled quantity times the average import value of high-carbon ferrochromium. Apparent supply monetary value estimated like apparent supply quantity with monetary value substituted for chromium content.

[10] Includes copper recovered from unalloyed and alloyed copper-base scrap, as refined copper or in alloy forms, as well as copper recovered from aluminum-, nickel-, and zinc-base scrap. Monetary value based on annual average refined copper prices.

[11] Recycled scrap reported from consuming manufacturers. Apparent supply measured as shipments of iron and steel products plus castings corrected for imported semifinished products. Recycled unit value is the U.S. annual average composite price for No. 1 heavy-melting steel calculated from prices published in American Metal Market. Unit value for the year used to calculate values of recycled scrap and apparent supply of scrap.

[12] Monetary value of scrap and apparent supply estimated based upon average quoted price of common lead.

[13] Includes magnesium content of aluminum-base scrap. Monetary value based on the annual average Platts Metals Week U.S. spot Western magnesium price.

[14] Nickel statistics were derived from the following:

Production, consumption, receipts

- Reported nickel content of products made from reclaimed stainless steel dust, spent nickel-cadmium batteries, plating solutions, and other products.
- Estimated nickel content of reported net receipts of alloy and stainless steel scrap.
- Reported nickel content of recovered copper-base scrap.
- Reported nickel content of obsolete and prompt purchased nickel-base scrap.
- Estimated nickel content of various types of reported obsolete and prompt aluminum scrap.

Trade data

- Reported nickel content of International Nickel Study Group (INSG) class I primary products, including briquets, cathode, flake, pellets, and powder.
- Reported or estimated nickel content of INSG class II primary products, including ferronickel, metallurgical-grade nickel oxide, and a variety of nickel-containing chemicals.
- Estimated nickel content of secondary products, including nickel waste and scrap and stainless steel scrap.

Stock data

- Reported or estimated nickel content of all scrap stocks, except copper.
- Reported nickel content of primary products held by world producers in U.S. warehouses.
- Reported nickel content of primary products held by U.S. consumers.
- Reported nickel content of U.S. Government stocks.

Monetary value based on annual average cash price for cathode, as reported by the London Metal Exchange.

TABLE 1—Continued
SALIENT U.S. RECYCLING STATISTICS FOR SELECTED METALS[1]

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[15] Monetary value based on Platts Metals Week composite price for tin. Apparent supply excludes withheld stock changes.

[16] Percentage recycled based on titanium scrap consumed divided by primary sponge and scrap consumption.

[17] Monetary value based on annual average Platts Metals Week metal price for North American special high-grade zinc.

TABLE 2
SALIENT U.S. RECYCLING TRADE STATISTICS FOR SELECTED METALS[1]

	Exports			Imports for consumption		
	Quantity			Quantity		
Year	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)
Aluminum:						
2006	1,480,000	NA	$2,550,000	527,000	NA	$930,000
2007	1,550,000	NA	3,050,000	471,000	NA	803,000
2008	1,980,000	NA	3,420,000	494,000	NA	853,000
2009	1,660,000	NA	22,100,000	433,000	NA	503,000
2010	1,910,000	NA	3,190,000	504,000	NA	763,000
Chromium:[2]						
2006	506,000	86,300	720,000	180,000	30,600	210,000
2007	882,000	150,000	1,620,000	118,000	20,400	200,000
2008	1,000,000	170,000	1,190,000	140,000	24,300	220,000
2009	1,130,000	192,000	778,000	124,000	21,200	138,000
2010	937,000	159,000	937,000	196,000	33,700	307,000
Copper:[3]						
2006	803,000	662,000	2,350,000	118,000	91,600	474,000
2007	907,000	704,000	2,840,000	133,000	112,000	665,000
2008	908,000	688,000	2,960,000	106,000	85,700	480,000
2009	843,000	633,000	2,010,000	71,800	56,300	234,000
2010	1,030,000	788,000	3,550,000	95,800	75,000	399,000
Iron and steel:						
2006	14,100,000	14,100,000	4,270,000	5,000,000	5,000,000	1,310,000
2007	16,700,000	16,700,000	6,980,000	3,780,000	3,780,000	1,080,000
2008	21,500,000	21,500,000	10,400,000	3,600,000	3,600,000	1,450,000
2009	22,400,000	22,400,000	7,120,000	2,990,000	2,990,000	814,000
2010	20,500,000	20,500,000	8,380,000	3,780,000	3,780,000	1,420,000
Lead:[4]						
2006	121,000	121,000	37,200	1,800	1,510	1,650
2007	129,000	129,000	55,400	1,590	1,400	2,740
2008	175,000	175,000	92,800	1,470	1,290	2,040
2009	140,000	140,000	72,000	1,600	1,310	2,620
2010	43,500	43,500	33,800	5,020	3,730	8,880
Magnesium:						
2006	3,680	3,680	8,410	17,200	17,200	23,700
2007	1,800	1,800	4,000	21,200	21,200	35,500
2008	2,600	2,600	5,420	24,100	24,100	58,800
2009	2,280	2,280	5,200	20,900	20,900	40,300
2010	481	481	802	22,100	22,100	56,500

See footnotes at end of table.

TABLE 2—Continued

SALIENT U.S. RECYCLING TRADE STATISTICS FOR SELECTED METALS[1]

	Exports			Imports for consumption		
	Quantity			Quantity		
Year	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained weight (metric tons)	Value (thousands)
Nickel:[5]						
2006	2,890,000	68,600	$1,730,000	717,000	22,400	$416,000
2007	2,800,000	110,000	3,110,000	826,000	19,000	488,000
2008	2,720,000	101,000	2,670,000	788,000	22,600	613,000
2009	2,420,000	95,100	1,710,000	699,000	20,000	442,000
2010	1,870,000	84,000	1,870,000	954,000	26,700	711,000
Tin:						
2006	7,500	7,500	14,100	2,490	2,490	4,470
2007	9,930	9,930	26,900	10,200	10,200	7,430
2008	10,300	10,300	26,600	23,300	23,300	17,700
2009	9,430	9,430	25,600	80,600	80,600	16,200
2010	10,700	10,700	26,500	57,300	57,300	18,300
Titanium:[6]						
2006	10,800	NA	110,000	12,800	NA	200,000
2007	9,510	NA	67,300	12,200	NA	133,000
2008	8,180	NA	52,000	10,400	NA	68,900
2009	4,200	NA	14,000	4,770	NA	17,600
2010	3,480	NA	19,200	10,700	NA	75,500
Zinc:						
2006	83,800	NA	95,800	14,200	NA	18,700
2007	102,000	NA	103,000	21,800	NA	32,500
2008	91,000	NA	99,100	17,000	NA	20,300
2009	47,100	NA	54,300	9,100	NA	8,800
2010	77,900	NA	85,200	15,600	NA	19,400

NA Not available.

[1] Contained weight based upon 100% of gross, unless otherwise specified.

[2] Includes stainless steel scrap and chromium metal waste and scrap. Contained weight for import and export quantities of Harmonized Tariff Schedule of the United States (HTS) code 7204.21.0000 is 17% of gross weight; 8112.22.0000 is 100% of gross weight.

[3] For HTS codes 7404.00.0045, 7404.00.0062, and 7404.00.0080 contained weight for import quantity is 65% of gross weight. For HTS codes 7404.00.3045, 7404.00.3055, 7404.00.3065, 7404.00.3090, 7404.00.6045, 7404.00.6055, 7404.00.6065, and 7404.00.6090 contained weight for import quantity is 72%.

[4] Lead content of waste and scrap obtained from lead-acid batteries (HTS 7802.00.0030) included in exports but excluded from imports.

[5] Contained weight for import and export quantities is 0.4% of gross weight for HTS code 7204.29.0000, 50% for HTS code 7503.00.0000, and 7.5% for HTS code 7204.21.0000.

[6] Includes titanium waste and scrap HTS code 8108.30.0000.

RHENIUM

By Désirée E. Polyak

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

U.S. estimated rhenium production increased by about 9%, while apparent consumption of rhenium increased by about 27% from that of 2009 (table 1). World production of rhenium in 2010 was estimated to be about 47,200 kilograms (kg), a 4% increase from that of 2009 (table 4).

Production

In the United States, rhenium is a byproduct of molybdenite concentrates that are recovered as a byproduct of porphyry copper-molybdenum ore mined in the Western States. Rhenium recovery requires roasting in a facility equipped to capture the rhenium compounds in the stack gases. In the United States, only one molybdenum concentrate roasting facility is currently so equipped—the Freeport McMoRan Copper & Gold Inc. Sierrita facility in Arizona. Domestic mine production data for rhenium (table 1) were derived by the U.S. Geological Survey (USGS) from reported molybdenum production at the copper-molybdenum mines. Domestic demand for rhenium metal and other rhenium products was met by imports, from recovery from domestic ores and stocks, and from the recycling of both spent catalysts and superalloy scrap.

Consumption

In the past decade, the two most important uses of rhenium have been in high-temperature superalloys and platinum-rhenium catalysts. Rhenium is used in single-crystal, high-temperature superalloy turbine blades for aircraft engines and land-based turbine applications. Rhenium is used in the turbine blades closest to the combustion zone in gas turbine engines. The use of rhenium-containing blades allows the engine to be designed with closer tolerances and allows operation at higher temperatures, which prolongs engine life and increases engine performance and operating efficiency. Platinum-rhenium catalysts are used to produce high-octane, lead-free gasoline. Industry continued to research the potential for increased recycling of rhenium-bearing turbine blades and the development of new alloys and catalysts.

Other applications of rhenium, primarily as tungsten-rhenium and molybdenum-rhenium alloys, are more diverse; these included crucibles, electrical contact points, electromagnets, electron tubes and targets, flashbulbs, heating elements, ionization gauges, mass spectrographs, metallic coatings, semiconductors, temperature controls, thermocouples, vacuum tubes, and x-ray tubes.

World consumption of rhenium in 2009 was estimated to be 53,500 kg, of which 78% was consumed in superalloys, 14% in catalysts, and 8% in other end uses (Roskill Information Services Ltd., 2010, p. 27).

Rhenium was used in petroleum-reforming catalysts for the production of high-octane hydrocarbons, which are used in the formulation of lead-free gasoline. Bimetallic platinum-rhenium catalysts have replaced many of the monometallic catalysts. Rhenium catalysts tolerate greater amounts of carbon formation when making gasoline, and make it possible to operate the production process at lower pressures and higher temperatures, which leads to improved yields (production per unit of catalyst used) and higher octane ratings. Platinum-rhenium catalysts also were used in the production of benzene, toluene, and xylenes, although this use was small compared with that used in gasoline production.

General Electric Aviation (GE), a subsidiary of General Electric Co. (Fairfield, CT), announced that it had developed two new alloys as part of the company's overall strategy to conserve and recycle rhenium. The first new alloy, N500, a rhenium-free alloy, was expected to be used in stationary parts such as engine nozzles and shrouds. The second new alloy, René N515, used less rhenium (1.5%) while providing the properties of other second-generation alloys that used significantly more rhenium (3%). According to the company, René N515 has been tested extensively and has been introduced into the CFM56 turbine blades in jet engines. Computer modeling enabled the development and introduction of the alloy in 2 years, compared to the traditional developmental time of 4 years (Fink and others, 2010). However, it was important to note that René N515 has been described as having an oxidation resistance capability at 1,175 °C. This temperature was not expected to be an operating temperature that could power many of the larger jet engines that run at higher temperatures. The only alloys capable of running at these higher temperatures were the current second-generation (3% Re) and third-generation (6% Re) alloys, making GE's new alloys inadequate for larger jet engines (Lipmann Walton & Co. Ltd., 2010).

GE has also been working to lessen its dependence on rhenium by researching a variety of innovative component designs and by using advanced manufacturing processes. Recycling materials from unserviceable engine parts continued to be performed through GE's Reclamation Program that was launched in 2006 in response to the volatile market and rising prices. GE recycles used, high-pressure turbine blades (HPTBs) made of a rhenium-bearing nickel superalloy that are cleaned and melted for reuse in manufacturing new HPTBs. Although the lifespan of engine parts was variable, a turbine blade was expected to last approximately 10 years. According to the company, more than 10% of its rhenium came from recycling, and it expected the percentage to increase in 2010 (General Electric Aviation, 2011).

According to the company, GE's Reclamation Program also has numerous benefits for its customers, who receive significant value for the scrap metal they return. The U.S. Navy was one of the first participants in the program. Approximately 23 metric tons (t) of material has been picked up from the U.S. Navy's Fleet Readiness Center (Jacksonville, FL) and recycled. That includes out-of-use F414, F404, and T700 engines, which are also some of the models that have the highest rhenium content (General Electric Aviation, 2011).

Rio Tinto plc announced that Kennecott Utah Copper's molybdenum autoclave-process (MAP) facility, first approved in June 2008 and then later put on hold, was given approval to restart construction in April 2010. First production from phase I of the project was anticipated in the fourth quarter of 2012, and production at full capacity of 13,600 metric tons per year (t/yr) of molybdenum was scheduled for the fourth quarter of 2013. The phase 2 expansion to 27,200 t/yr of molybdenum was anticipated to be completed in the first quarter of 2015 (Rio Tinto plc, 2011, p. 78). The MAP was expected to enable lower grade concentrate to be processed more efficiently than in conventional roasters, to allow improved molybdenum recovery, and to enable production of chemical-grade molybdenum products (Rio Tinto plc, 2010, p. 40). The new facility would have the capacity to recover approximately 3 to 5 t/yr of rhenium. Unlike the roasting process, the autoclave system would extract rhenium at the crystallization stage and recover it, as in the old roasting process, via ion exchange. The final products would be high-purity ammonium perrhenate (APR) suitable for catalysts and rhenium metal for the aerospace industry.

Northern Dynasty Minerals Ltd. (Vancouver, British Columbia, Canada) announced the results of a preliminary assessment technical report from its Pebble copper-gold-molybdenum-rhenium project in Alaska. Based on a 45-year open pit mine life, the report estimated that the project could produce close to 14 million metric tons of copper, 635,000 t of molybdenum, and 1,200 t of rhenium, in addition to gold, palladium, and silver. Mine construction would take 4 years, employing a maximum labor force of 2,080. The project, also known as the Pebble Partnership, is a 50-50 joint venture between Northern Dynasty and Anglo American plc (London, United Kingdom). According to the companies, a range of options are currently being examined including conventional open pit mining, underground mining, or a combination of both (Northern Dynasty Minerals Ltd., 2011, p. 10–13).

Prices

In 2010, the annual average price of APR catalytic-grade rhenium as reported in Metal Bulletin was $4,630 per kilogram, a 39% decrease compared with the $7,580 per kilogram annual average price of 2009. The annual average price of rhenium metal pellets (minimum 99.9%) was $4,720 per kilogram in 2010, a 37% decrease from the $7,500 per kilogram annual average price of 2009. The rhenium metal pellet price was $4,740 per kilogram until July, when it trended downward for the remainder of the year.

Foreign Trade

Imports of rhenium metal in 2010 increased to 23,100 kg, a 7% increase compared with 21,500 kg rhenium metal in 2009 (table 2). Imports of APR increased to 25,500 kg, a 78% increased compared with 14,300 kg APR in 2009, owing to stronger U.S. demand (table 3). Chile and the United Kingdom were the leading suppliers of rhenium metal to the United States; Kazakhstan, Poland, Russia, and the United Kingdom were the leading suppliers of APR. Imports for consumption of rhenium metal are shown in tables 1 and 2, and those of APR are shown in tables 1 and 3.

World Review

World production of rhenium was estimated to have been about 47,200 kg in 2010 (table 4). This estimate was based on the quantity of rhenium recovered from concentrates that were processed to recover rhenium values.

Rhenium was recovered as a byproduct from porphyry copper-molybdenum ores mined primarily in Canada, Chile, Mexico, Peru, Poland, and the United States. Rhenium is also associated with copper minerals in sedimentary deposits in Armenia, Kazakhstan, Russia, and Uzbekistan, where ore is processed for copper recovery, and the rhenium-bearing residues are recovered at the copper smelter. Rhenium-bearing residues from both sources are processed for recovery either as APR for catalyst uses, or as a metal powder for superalloys. The major producers of rhenium metal and compounds were Chile, Germany, the Netherlands, the United Kingdom, and the United States.

World reserves of rhenium are contained primarily in molybdenite in porphyry copper deposits. U.S. reserves of rhenium are concentrated in Arizona, Montana, Nevada, New Mexico, and Utah. Chilean reserves are found primarily at four large porphyry copper deposits and in smaller deposits in the northern half of the country. In Peru, reserves are concentrated primarily in the Toquepala open pit porphyry copper mine and in about 12 other deposits. Other world reserves are contained in several porphyry copper deposits and sedimentary copper deposits in Armenia, northwestern China, Iran, Kazakhstan, Russia, and Uzbekistan, and in sedimentary copper-cobalt deposits in Congo (Kinshasa). U.S. reserves were estimated to be about 390 t, and rest-of-the-world reserves were estimated to be about 2,100 t.

Australia.—Ivanhoe Australia Ltd. (Melbourne) announced that it completed a prefeasibility study on its Merlin molybdenum-rhenium project in northwestern Queensland. The prefeasibility study projected average output of approximately 5,300 t/yr of molybdenum as molybdenum trioxide and 7.2 t/yr of rhenium as APR during at least a 10-year mine life. Concentrate production was targeted for the third quarter of 2013, with commercial production to start in the first quarter of 2014 (Metal-Pages, 2011).

Chile.—Molibdenos y Metales S.A. (Molymet) (Santiago) maintained roasting facilities equipped for rhenium recovery in Belgium, Chile, and Mexico. Molymet primarily toll roasted byproduct molybdenum concentrates for Corporación Nacional del Cobre de Chile (Codelco), but also sourced concentrates from Canada, Mexico, Peru, and the United States. Codelco and Xstrata plc also roasted byproduct molybdenum concentrates in Chile, but those roasters were not equipped for rhenium recovery.

In January, Codelco resubmitted approval plans to Chile's National Environmental Comission (CONEMA) for its $4.5 million plan to refurbish and restart operation of a rhenium recovery plant at its Chuquicamata Mine. In November 2009, the company had submitted a request but later withdrew it in order to carry out some technical adjustments. The plant was expected to have the capability to produce 1,800 kilograms per year of metallic rhenium and was expected to run for 20 years (Business News Americas, 2010). The rhenium recovery plant was built in 1990 and began production in 1991, but operations were halted in 1996 after rhenium market conditions deteriorated (Platts Metals Week, 2009).

Kazakhstan.—Zhezkazganredmet (Redmet), Kazakhstan's state-owned rhenium producer, received rhenium-bearing residues from the Dzhezkazgan Copper Works mine and smelter complex in Kazakhstan. Dzhezkazgan was controlled by Kazakh Copper, and its parent Samsung Corp., which received 50% of Redmet's production as payment for the rhenium residues. A disagreement, beginning in 2007, between Kazak Copper and Redmet resulted in rhenium production slipping from 8 t in 2006 to an estimated 3 t in 2009. The Dzhezkazgan plant was scheduled to undergo refurbishment in 2010, which further decreased rhenium production to an estimated 2 t in 2010 (Kazakhmys plc, 2010).

Poland.—KGHM Ecoren S.A. (Lubin), a division of Polish copper producer KGHM Polish Copper S.A., opened a metallic rhenium refinery near the Legnica Copper Smelter. The facility, completed in October 2009, took only 5-1/2 months to build. Ecoren reported that British customers, Rolls-Royce Group plc and Johnson Matthey plc, were the major purchasers of its rhenium products. The facility has an annual capacity to convert APR into 3.5 t of metallic rhenium. It is also able to supply rhenium metal in powder form according to customer's requirements. Ecoren also increased its crystalline APR production capacity, which was expected to be 6 to 7 t/yr of APR. Ecoren receives the waste sulfuric acid from the KGHM Polish copper plant and then, through hydrometallurgical processes, captures the rhenium to produce the APR and rhenium metal (KGHM Ecoren S.A., 2011).

Outlook

The global economic downturn, particularly in North America and Europe, severely affected the major markets for rhenium, and world rhenium demand decreased by 16% in 2009. In 2010, rhenium demand began to recover. The United States is the world's leading producer of aerospace superalloys and is, therefore, the largest consumer of rhenium (Roskill Information Services Ltd., 2010, p. 34). With the leading three consumers—GE, Pratt & Whitney, and Cannon Muskegon Corp.—consuming an estimated 45 t/yr of rhenium, more production from new plants, such as Poland's new rhenium facility, are needed. Rhenium consumption was estimated to increase by an average of 5% per year between 2009 and 2015 to reach 71,500 kg in 2015 (Roskill Information Services Ltd., 2010, p. 27).

As the life cycle of turbine blades in jet engines is approximately 10 years, significant quantities of second-generation blades (3% Re) were accumulating. Technology is beginning to be developed to allow recycling of second-generation blades for recovery of rhenium that can be used in the manufacture of new third-generation blades, potentially reducing requirements for virgin rhenium by about 50%. The majority of rhenium is recycled in Germany and the United States, but significant amounts are also being recovered in Estonia and Russia.

Potential molybdenum producers continued to look at ways to increase the value of future production since the collapse in the molybdenum price. For some, producing byproduct rhenium is a strong possibility. Perhaps the greatest potential for increased rhenium production lies in the molybdenum concentrates that are presently being roasted in facilities that are not equipped to recover the rhenium values. For example, Rio Tinto's new MAP facility would allow Rio Tinto to recover approximately 3 to 5 t/yr of rhenium, potentially increasing U.S. rhenium production by more than 50%.

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TABLE 1
SALIENT U.S. RHENIUM STATISTICS[1]

(Kilograms, gross weight)

	2006	2007	2008	2009	2010
Production[2, 3]	8,100	7,100	7,900	5,600	6,100
Apparent consumption[e, 4]	46,900 [r]	48,100 [r]	51,600 [r]	37,100 [r]	46,900
Imports:					
Metal	22,000	30,500	35,900	21,500	23,100
Ammonium perrhenate	24,300	15,100	11,200	14,300	25,500

[e]Estimated. [r]Revised.

[1] Data are rounded to no more than three significant digits unless otherwise specified.

[2] Rhenium contained in molybdenite concentrates, based on calculations by the U.S. Geological Survey.

[3] Data are rounded to two significant digits.

[4] Calculated as production plus imports minus exports and industry stock changes.

TABLE 2
U.S. IMPORTS FOR CONSUMPTION OF RHENIUM METAL, BY COUNTRY[1]

	2009		2010	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Canada	39	$73	10	$21
Chile	20,100	47,200	21,900	50,200
Germany	1,030	3,820	314	520
Italy	--	--	89	584
Netherlands	219	1,940	--	--
Poland	--	--	7	24
United Kingdom	119	61	771	1,430
Total	21,500	53,100	23,100	52,800

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau, as adjusted by the U.S. Geological Survey.

TABLE 3

U.S. IMPORTS FOR CONSUMPTION OF AMMONIUM PERRHENATE, BY COUNTRY[1]

	2009		2010	
Country	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
Canada	--	--	96	$275
Chile	4,800	$361	--	--
Germany	--	--	2,890	813
Kazakhstan	--	--	4,590	3,530
Mongolia	2,390	180	--	--
Netherlands	1	4	2,850	1,250
Poland	1,870	698	4,100	8,270
Russia	--	--	3,770	1,060
United Kingdom	5,260	12,400	6,070	2,410
Uzbekistan	--	--	1,090	308
Total	14,300	13,700	25,500	17,900

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau, as adjusted by the U.S. Geological Survey.

TABLE 4

RHENIUM: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

Country	2006	2007	2008	2009	2010
Armenia	1,200	400	400	400	400
Canada	1,200	1,200	1,600	1,000 [r]	1,000 [p]
Chile[3]	19,800	22,900	27,600	25,000	25,000
Kazakhstan	8,000	5,500	5,500	3,000	2,000
Peru[4]	5,000	5,000	5,000	5,000	5,000
Poland[5]	1,000 [r]	2,400 [r]	3,400 [r]	2,400 [r]	4,700
Russia	1,400	1,500	1,500	1,500	1,500
United States[6, 7]	8,100	7,100	7,900	5,600	6,100
Uzbekistan	NA	NA	NA	NA	NA
Other	1,000	1,500	2,000	1,500	1,500
Total	46,700	47,500	54,900	45,400 [r]	47,200

[p] Preliminary. [r] Revised. NA Not available.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through June 27, 2011.

[3] Data also includes rhenium content from Belgium, Mexico, and the United States, processed at Molymet in Chile.

[4] No rhenium is recovered in Peru, but unroasted molybdenum concentrates containing rhenium are exported to Molymet in Chile for processing.

[5] Data based on new information from KGHM Ecoren S.A. Calculated based on 69.2% rhenium content of ammonium perrhenate.

[6] Reported figure.

[7] Calculated rhenium contained in molybdenite concentrates. Data rounded to two significant digits.

SALT

By Dennis S. Kostick

Domestic survey data and tables were prepared by Martha L. Jackson, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

The United States was the world's leading salt producing nation until 2005, when China surpassed the United States to become the leading producing country in the world. Total U.S. salt production in 2010 decreased by 6% to 43 million metric tons (Mt) compared with that of 2009 (table 1). According to U.S. Geological Survey (USGS) data for 2010, 28 companies operated 60 salt-producing plants in 16 States. Of these, 10 companies and 13 plants produced more than 1 Mt each and accounted for 91% and 69%, respectively, of total U.S. production and accounted for 61% and 36%, respectively, of total value. Several companies and plants produced more than one type of salt. In 2010, 13 companies (25 operations) produced salt brine; 11 companies (15 operations), rock salt; 9 companies (12 operations), solar-evaporated salt; and 7 companies (17 operations), vacuum pan salt.

The five leading States were, in descending order of total salt sold or used, Louisiana with 32%; Texas, 21%; New York, 15%; Kansas, 7%; and Utah, 5%. Other Eastern States (Alabama, Michigan, Ohio, Tennessee, Virginia, and West Virginia) accounted for 17% of the domestic total salt sold or used. Other Western States (Arizona, California, Nevada, New Mexico, and Oklahoma) represented 3% (table 5).

Salt, also known as sodium chloride, comprises the elements sodium and chlorine. Sodium is a silver-colored metal that is so unstable that it reacts violently in the presence of water, and chlorine is a greenish-colored gas that is dangerous and may be lethal, yet combined, these two elements form sodium chloride, which is a white-colored compound essential to life itself. Virtually every person in the world has some direct or indirect contact with salt daily. People routinely add salt to their food as a flavor enhancer or apply rock salt to walkways to remove ice in the winter. Salt is used as feedstock for chlorine and caustic soda manufacture. These two inorganic chemicals are used to make many consumer-related end-use products, such as polyvinyl chloride (PVC), a plastic made from chlorine, and paper-pulping chemicals manufactured from sodium hydroxide (caustic soda).

Production

U.S. production and sales data for salt are developed by the USGS from an annual voluntary survey of U.S. salt-producing sites and company operations (table 2). Production refers to the quantity of salt mined or manufactured that is available for sale. Salt sold or used is the quantity of salt that was sold directly to customers or used by the salt producer, which usually is a chloralkali (chlorine and sodium hydroxide) manufacturer. The data in table 2 are rated capacities for mines and refineries as of December 31, 2010. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant, and given acceptable routine operating procedures involving energy, labor, maintenance, and materials.

Of the 28 companies to which a canvass form was sent, 25 responded, representing 92% of the totals shown in this report. Data for the nonrespondents were estimated based on their prior responses to previous annual surveys, the 2010 production estimate survey, or brine production capabilities for chloralkali manufacture based upon published chlorine production capacities [1.75 metric tons (t) of salt required per ton of chlorine capacity].

The structure of the U.S. salt industry has changed throughout the years. In 1970, 50 companies operated 95 salt-producing plants in the United States. Market competition, increased energy and labor costs, less expensive imports, fluctuations in currency exchange rates, and an excess of production capacity (resulting in the downsizing of the industry through mergers and acquisitions) reduced the number of operations in the industry to 28 companies and 60 plants by 2009.

The four types of salt that are surveyed are classified according to the method of recovery as follows: rock salt, from the surface or underground mining of halite deposits; solar salt, from the solar evaporation of seawater, landlocked bodies of saline water, or primary or byproduct brines; vacuum pan salt, from the mechanical evaporation of a purified brine feedstock; and brine, from the solution mining of underground halite deposits. Data for brine production and consumption represent the anhydrous salt content only and not the weight of the water.

Rock Salt.—Rock salt is mined by the room-and-pillar method, which is similar to that used in coal and trona mining. Additional information about rock salt mining can be found in the salt chapter in Minerals Yearbook 2006.

Because the majority of rock salt was used for deicing, the operating rate of rock salt facilities fluctuated with the demand for deicing salt, again dependent on the severity of winter weather conditions. During periods of strong demand, production levels often achieve or exceed in certain situations, the rated capacities. Full mine capacity generally is a function of the hoisting capabilities of the mine. Assuming that the work week is 5 days (250 workdays per year), two working shifts and one maintenance shift per day, and at least one short-term planned turnaround for the mine and mill per year, table 2 lists the production capacities for domestic rock salt operations. In 2010, rock salt mining was 15.8 Mt, a 22% decrease compared with the 2009 total of 20.3 Mt.

Solar Evaporation.—Solar salt production was 4.83 Mt in 2010, which was a 24% increase from the 2009 total of 3.88 Mt. Solar evaporation uses the wind and the sun to evaporate the water and is an effective method of producing solar salt in areas of high evaporation and low precipitation. Additional information about solar salt production can be found in the 2006 salt Minerals Yearbook chapter.

Because evaporation rates must exceed the precipitation rates, the climatic conditions and geographic locations of solar evaporation facilities are critical to the successful production and harvesting of solar salt. Therefore, rated capacities in table 2 generally are based on the historical evaporation patterns within a region and vary depending on the location and the surface acres of the evaporation ponds. Only unpredictable seasonal precipitation and market conditions usually affect the production rates of the facilities.

Solution Mining.—U.S. salt brine production in 2010 was 18.5 Mt, which was about 4% more than the 2009 total of 17.8 Mt. The brine production capacities for table 2 are difficult to derive because they are based on the variabilities of the injection rate of the solvent and the solubility rates of the underground salt bodies, both of which determine the quantity of brine produced. In turn, these production levels are usually dependent on the demand for the products that the brine is being used to manufacture. Brine capacity is assumed to be equal to the amount of annual brine production. In order to avoid revealing company proprietary data, individual company brine capacities are not included in table 2.

Solution mining is used to obtain a sodium chloride feedstock for vacuum pan salt production and for chlorine, caustic soda, and synthetic soda ash (excluding the United States) manufacture. The quantity of underground salt dissolved and recovered as brine to make vacuum pan salt usually is not reported as primary salt production; only the quantity of vacuum pan salt manufactured is reported. The quantity of brine used to make chloralkali chemicals is reported as either the amount of captive brine used or brine sold. The chemical industry is the leading consumer of salt brine worldwide. Additional information about salt brine production can be found in the 2006 salt Minerals Yearbook chapter.

Mechanical Evaporation.—Vacuum pan salt is not mined but is a type of salt produced using mechanical evaporation technology. Vacuum pan salt production was 4.10 Mt in 2010, which was a slight increase compared with the 2009 total of 4.03 Mt. The mechanical evaporation of salt by the vacuum pan process is dependent on the number and size of the vacuum crystallizers operating in series. Rated capacities in table 2 are usually easier to establish because of the proven design performance of the equipment.

Although rock salt, solar salt, and salt brine may be used to make vacuum pan salt, virtually all domestic vacuum pan salt is obtained from solution mining of underground salt formations. Vacuum pan salt is obtained by dehydrating brine using heat alone or in combination with a vacuum. The grainer or open pan process uses open, rectangular pans with steam-heated immersion coils to evaporate the water in the brine. The final product is usually flake shaped rather than the typical cubic form. Flake salt is preferred for the production of baked goods, butter, and cheese. The Alberger process is a modified grainer operation that produces cubic salt with some flake salt.

In October 2010, the Detroit Salt Co., LLC was acquired by the Kissner Group of Canada for an undisclosed price. The mine opened in 1906 and produced rock salt for deicing until about 1982, when the operation closed. It was purchased in 1997 and began operating as Detroit Salt. The Kissner Group was formed in 1878 and sold milled crops and agricultural salt products to local farmers. With the purchase of Detroit Salt, Kissner operates 14 facilities in Canada and the United States (Duggan, 2010).

Consumption

In 2010, apparent consumption (salt sold or used plus imports minus exports) was 55.8 Mt, whereas reported consumption (sales or use as reported by the salt companies, including their imports and exports) was 48.6 Mt. Although these two measures of consumption are not necessarily expected to be identical, they normally are similar. Apparent consumption normally is greater than reported consumption because apparent consumption includes additional quantities of salt imported and exported by nonsalt-producing companies, such as some chloralkali operations and salt distributors. Reported consumption statistics are those reported only by the domestic salt producing companies.

The direct and indirect uses of salt number about 14,000, according to industry sources. The USGS annually surveys eight major categories comprising 29 end uses. The 2010 reported percentage distribution of salt by major end use was chemicals, 42%; ice control, 38%; distributors (grocery and other wholesalers and retailers, and so forth), 8%; agricultural and food processing, 4% each; general industrial and primary water treatment, 2% each; and other uses combined with exports, less than 1% (table 6). Distributors represented a substantial share of salt sales by the salt industry; all this salt is ultimately resold to many different end users. For a more complete analysis of end-use markets, specific sectors of distribution in table 6 can be combined, such as agricultural and water treatment with agricultural and water conditioning distribution, respectively.

Aside from the different types of salt, there are various distinctions in the packaging and applications of salt. Salt for human consumption is packaged in different sized containers for several specialized purposes. Table salt may contain 0.01% potassium iodide as an additive, which provides a source of iodine that is essential to the oxidation processes in the body. Kosher salt, sea salt, condiment salt, and salt tablets are special varieties of salt.

Chemical Industry.—For most years, the leading consumer of salt, primarily as salt brine, is the chemical industry. Salt brine is extracted from natural underground saline sources or solution-mined halite deposits (salt beds or salt domes), or produced through the dissolution of solar salt. Within this industry, the chloralkali sector remains the major consumer of salt for manufacturing chlorine, coproduct sodium hydroxide (caustic soda), and synthetic soda ash. Since 1986, when the last domestic synthetic soda ash plant was closed because of high production costs and competition with less expensive natural soda ash, no synthetic soda ash has been manufactured in the United States; many countries, however, still produce synthetic soda ash and use vast quantities of salt brine as feedstock. Total salt sold or used by the chemical industry was 20.2 Mt in 2010, of which 19.1 Mt was for chloralkali manufacture and 1.09 Mt was for other chemical uses (table 6).

Salt is used as the primary raw material in chlorine manufacture because it is an inexpensive and widely available source of chlorine ions. For sodium hydroxide production, salt is the main source of sodium ions. Chlorine and caustic soda are considered to be the first generation of products made from salt. These two chemicals are further used to manufacture other materials, which are considered to be the second generation of products made from salt. Although most salt brine is produced by the same companies that use it, many chloralkali manufacturers now purchase brine from independent brine supply companies. In certain cases, brine is produced by a chemical company that uses some of it and sells the excess to neighboring competitors. According to industry sources, about 48% of the salt used to manufacture chlorine was captive (produced by the chloralkali companies) and 31% was purchased brine; domestically purchased solar salt and rock salt made up 12% of the supply, and imported rock, solar, and vacuum pan salt, 9%.

In 2010, according to the U.S. Census Bureau, 9.72 Mt of chlorine and 7.48 Mt of sodium hydroxide (caustic soda or lye) were produced in the United States (U.S. Census Bureau, 2010). Based on the industry average ratio of 1.75 t of salt required to produce 1.0 t of chlorine and 1.1 t of coproduct sodium hydroxide, the chlorine and caustic soda industry consumed about 17.0 Mt of salt for feedstock. Reported consumption of total domestic and imported salt for chlorine manufacture was 19.1 Mt (table 6). Typically, the difference between the calculated and reported quantities was the amount of salt not reported to the USGS from imports or captive brine production of chloralkali producers. In 2010, the difference of about 2 Mt have been because of unreported chlorine production data.

Salt is also used as a feedstock in chemical plants that make sodium chlorate, metallic sodium, and other downstream chemical products. In powdered soaps and detergents, salt is used as a bulking agent and a coagulant for colloidal dispersion after saponification. In pharmaceuticals, salt is a chemical reagent and is used as the electrolyte in saline solutions. It is used with sulfuric acid to produce sodium sulfate and hydrochloric acid. The "Other chemical" subsector is relatively small, representing about 5% of domestic salt sales for the entire chemical sector and only 2% of total domestic salt consumption. The consumption of salt for metallic sodium has declined during the past several years. E.I. du Pont de Nemours and Co. was the sole manufacturer of metallic sodium in the United States. The domestic market for metallic sodium decreased because sodium metal was no longer needed for the production of leaded gasolines. The leading use of sodium was for sodium borohydride production, which is the feedstock for sodium dithionite used as a reductive bleaching agent by the pulp and paper industry. Sodium metal also is used to manufacture sodium azide, which is used in automotive air bags. Other potential uses of sodium metal are in the remediation of chemical weapons, chlorofluorocarbons, pesticides, and polychlorinated biphenyls.

Ice Control and Road Stabilization.—In 2010, U.S. consumption of salt for this application was 18.7 Mt, which was about 11% more than that of 2009. Additional imports of rock salt by the salt companies were available if needed during 2010.

Salt is an inexpensive, widely available, and effective ice control agent. It does, however, become less effective as the temperature decreases below about 6.5 °C to 9.5 °C (15 °F to 20 °F). At lower temperatures, more salt must be applied to maintain higher brine concentrations to provide the same degree of melting. Most winter snowstorms and ice storms happen when temperatures are between 4 °C and 0 °C (25 °F and 32 °F), the range in which salt is most effective.

In highway deicing, salt has been associated with corrosion of bridge decks, motor vehicles, reinforcement bar and wire, and unprotected steel structures used in road construction. Surface runoff, vehicle spraying, and windblown actions also affect soil, roadside vegetation, and local surface water and groundwater supplies. Although evidence of environmental loading of salt has been found during peak usage, the spring rains and thaws usually dilute the concentrations of sodium in the area where salt was applied.

The quantity of salt consumed for road deicing each year is directly related to the severity of the winter weather conditions. Long-range forecasting of salt consumption in this application is extremely difficult because of the complexities in long-range forecasting of the weather.

Salt also is added to stabilize the soil and to provide firmness to the foundation on which highways are built. The salt acts to minimize the effects of shifting caused in the subsurface by changes in humidity and traffic load.

Distributors.—A large amount of salt is marketed through various distributors, some of which specialize in agricultural and water treatment services—two sectors in which the salt companies also have direct sales (table 6). Distributor sales also include grocery wholesalers and (or) retailers, institutional wholesalers, U.S. Government resale, and other wholesalers and retailers. Total salt sold to distributors was 4.02 Mt in 2010.

General Industrial.—The industrial uses of salt are diverse. They include, in descending order of quantity consumed, other industrial applications, oil and gas exploration, textiles and dyeing, pulp and paper, metal processing, tanning and leather treatment, and rubber manufacture. Total salt sold to these sectors was 931,000 t in 2010.

In oil and gas exploration, salt is an important component of drilling fluids in well drilling. It is used to flocculate and increase the density of the drilling fluid to overcome high downwell gas pressures. Whenever a drill hits a salt formation, salt is added to the drilling fluid to saturate the solution and to minimize the dissolution within the salt stratum. Salt is also used to increase the set rate of concrete in cemented casings.

In textiles and dyeing, salt is used as a brine rinse to separate organic contaminants, to promote "salting out" of dyestuff precipitates, and to blend with concentrated dyes to standardize them. One of its main roles is to provide the positive ion charge to promote the absorption of negatively charged ions of dyes.

In metal processing, salt is used in concentrating uranium ore into uranium oxide (yellow cake). It also is used in processing aluminum, beryllium, copper, steel, and vanadium.

In the pulp and paper industry, salt is used to bleach wood pulp. It also is used to make sodium chlorate, which is added along with sulfuric acid and water to manufacture chlorine dioxide, an excellent oxygen-based bleaching chemical. The chlorine dioxide process, which originated in Germany after World War I, is becoming more popular because of environmental pressures to reduce or eliminate chlorinated bleaching compounds.

In tanning and leather treatment, salt is added to animal hides to inhibit microbial activity on the underside of the hides and to attract moisture back into the hides. In rubber manufacture, salt is used to make buna, neoprene, and white types. Salt brine and sulfuric acid are used to coagulate an emulsified latex made from chlorinated butadiene.

Agricultural Industry.—Barnyard and grazing livestock need supplementary salt rations to maintain proper nutrition. In 2010, 1.84 Mt of salt was sold to the agricultural industry. Animal feed and water conditioning salt are made into 22.7-kilogram (50-pound) pressed blocks. Iodine, sulfur, trace elements, and vitamins are occasionally added to salt blocks to provide nutrients not found naturally in the diet of certain livestock. Salt is also compressed into pellets that are used for water conditioning.

Food Processing.—Every person uses some quantity of salt in food. Approximately 80% of the sodium intake by people comes from processed and prepared foods. Aside from table salt, sodium is found in many processed foods, such as monosodium glutamate and baking soda. The salt is added to the food by the food processor or by the consumer as a flavor enhancer, preservative, binder, fermentation-control additive, texture-control agent, and color developer. This major category is subdivided, in descending order of salt consumption, into other food processing, meat packers, canning, baking, dairy, and grain mill products. Total salt sold for food processing was 1.76 Mt in 2010 (Los Angeles Times, 2010).

In meat packing, salt is added to processed meats to promote color development in bacon, ham, and other processed meat products. As a preservative, salt inhibits the growth of bacteria, which would lead to spoilage of the product. Salt acts as a binder in sausages to form a binding gel made up of meat, fat, and moisture. Salt also acts as a flavor enhancer and as a tenderizer.

In the dairy industry, salt is added to cheese as a color-, fermentation-, and texture-control agent. The dairy subsector includes companies that manufacture creamery butter, condensed and evaporated milk, frozen desserts, ice cream, natural and processed cheese, and specialty dairy products.

In canning, salt is primarily added as a flavor enhancer and preservative. It also is used as a carrier for other ingredients, dehydrating agent, enzyme inhibitor, and tenderizer.

In baking, salt is added to control the rate of fermentation in bread dough. It also is used to strengthen the gluten (the elastic protein-water complex in certain doughs) and as a flavor enhancer, such as a topping on baked goods.

The food-processing category also contains grain mill products. These products consist of milling flour and rice and manufacturing cereal breakfast food and blended or prepared flour.

In the "other food processing" category, salt is used mainly as a seasoning agent. This category includes miscellaneous establishments that make food for human consumption (such as potato chips and pretzels) and for domestic pet consumption (such as cat and dog food).

Many consumers are confused with the words salt and sodium and often think the two words are synonymous, but they are not. Medical experts agree that the daily sodium intake per person should be 2,300 milligrams (mg) or less, which is the equivalent of one teaspoon of salt, or 5.8 grams (gm). Each gram of salt contains 0.4 gm of sodium, and one gram of sodium is equal to 2.5 gm of salt (Downs, 2010; ScienceDaily, 2010).

A study in the New England Journal of Medicine (NEJM) in January stated that cutting dietary sodium by three grams daily could reduce coronary heart disease and strokes. The report claimed that if everyone reduced their daily salt intake by one-half teaspoon, there would be between 54,000 and 99,000 fewer heart attacks, between 32,000 to 66,000 fewer strokes, between 44,000 and 92,000 fewer deaths, and between 60,000 to 120,000 fewer new cases of coronary heart disease in the United States each year. In addition, the salt reduction would result in an annual savings of $24 billion in health care costs (Bibbins-Domingo and others, 2010).

The NEJM study received support by the New York City Department of Health and Mental Hygiene that endorsed draft guidelines that recommended a reduction of salt intake by 20% during a 5-year period. The recommendations also were endorsed by 25 other city or State agencies and 17 national health organizations (Caruso, 2010; Felten, 2010).

In an effort to address the concerns of excess sodium in the diet by the medical community and various government agencies, several major food processing companies voluntarily agreed to reduce the salt content in their processed foods. These companies found that consumers responded better to reducing their sodium intake when the sodium content was not emphasized on the labels. Foods that contained more than 500 mg of sodium per 100 gm were considered to be "high sodium" while foods with less than 120 mg of sodium per 100 gm were "low sodium." Many of the food processing companies began an effort to reduce the salt content in their food products by about 20% during a 3-year period as recommended by the NEJM study, so that the changes were not so noticeable (Brat and Tamman, 2010; RedOrbit Inc., 2010).

Many food processors began to use sea salt in their foods as a replacement for vacuum pan salt (table salt) as a more natural and healthy alternative. By weight, sea salt and table salt contain about the same amount of sodium chloride, and both have the same basic nutritional value. Sea salt is advertized and marketed as containing beneficial trace elements contained in seawater. According to the Mayo Clinic, these trace elements are virtually insignificant for human health but do add some flavor, larger crystal size, and color to the sea salt compared with the table salt that eliminates trace minerals and adds iodine and various free-flowing agents (Phillips, 2010; Zeratsky, 2010).

Water Treatment.—Many areas of the United States have hard water, which contains excessive calcium and magnesium ions that contribute to the buildup of a scale or film of alkaline mineral deposits in household and industrial equipment and pipes. Commercial and residential water-softening units use salt to remove the ions that cause the hardness. The sodium ions captured on a resin bed are exchanged for the calcium and magnesium ions. Periodically, the water-softening units must be recharged because the sodium ions become depleted. Salt is added and dissolved, and brine replenishes the lost sodium ions. In 2010, 913,000 t of salt was sold for primary water treatment and an additional 461,000 t was sold for water conditioning distribution.

Stocks

Because bulk salt is stored at many different locations, such as plants, ports, terminals, and warehouses, data on the quantity of salt stockpiled by the salt industry are not reliable enough to formulate accurate inventory totals; however, yearend stocks of producers were estimated to be 2 Mt, and consumer inventories also were estimated to be high. Most of these inventories were imported rock salt and solar salt. Many salt distributors, municipalities, road deicing contractors, salt producers, and States stockpiled additional quantities of salt in anticipation of adverse weather conditions. Deicing salt inventories were reduced by yearend 2010 because of moderately severe winter weather during late 2010. For the reasons discussed above, salt stocks are assumed to be the difference between salt production and salt sold or used in calculating apparent consumption.

Transportation

Because the locations of the salt supplies are not often near consumers, transportation may be an important cost. Pumping salt brine through pipelines is an economic means of transportation but cannot be used for dry salt. Large bulk shipments of dry salt in ocean freighters or river barges are low in cost but are restricted in points of origin and consumption. River and lake movement of salt in winter is often severely curtailed because of frozen waterways. As salt is packaged, handled, and shipped in smaller units, the costs increase and are reflected in higher selling prices.

Transportation costs significantly add to the price of salt. In some cases, shipping costs are higher than the actual value of the salt. Ocean vessels can transport greater quantities of salt than barge, rail, or truck shipments. Transoceanic imports of salt have been increasing in some areas of the United States because they are more cost competitive than salt purchased from domestic suppliers using barge, rail, or truck transportation. One important factor that often determines the quantity of salt that can be imported is the depth of the channels and the ports; many ports are not deep enough to accommodate larger ships.

Prices

The four types of salt that are produced have unique production, processing, and packaging factors that determine the selling prices. Generally, salt sold in bulk is less expensive than salt that has been packaged, pelletized, or pressed into blocks. Salt in brine is the least expensive salt sold because mining and processing costs are less. Vacuum pan salt is the most expensive because of the higher energy costs involved in processing and the purity of the product.

Price quotations are not synonymous with average values reported to the USGS. The quotations do not necessarily represent prices at which transactions actually took place, or bid and asked prices. The annual average values, as collected by the USGS and listed in table 8, represent a national average value for each of the types of salt and the various product forms.

Foreign Trade

Under Harmonized Tariff Schedule of the United States (HTS) nomenclature, imports are aggregated under one category named "Salt (including table and denatured salt) and pure sodium chloride, whether or not in aqueous solution, seawater." The same classification also applies to exports. The HTS code for salt is 2501.00.0000. The trade tables in this report list the previous and current identification codes for salt. Although several other HTS codes pertain to various salt classifications, the United States aggregates shipments under one code because the sums of individual subclassifications fail to meet the minimum dollar requirements necessary for individual listings.

Based on U.S. Census Bureau data for 2010, the United States exported 595,000 t of salt; this was a 59% decrease compared with that of 2009 (table 9). In 2010, the majority of exports (76%) were to Canada. Salt was shipped to 30 countries through 21 customs districts; the Detroit, MI, district exported the most and represented 32% of the U.S. total (table 10). Based on U.S. Census Bureau statistics, the United States imported 12.9 Mt of salt from 39 countries in 2010, which was 12% less than was imported during 2009 (table 11). Chile was the leading source of imports, representing about 39% of total imports, followed closely by Canada (33%). Table 12 lists the imports of salt by customs districts. Of the 40 customs districts that imported salt in 2010, the New York, NY, customs district was the largest in terms of tonnage, accounting for about 16% of the total, followed by Baltimore, MD (13%); Philadelphia, PA (12%); Boston, MA (9%); Chicago, IL (7%); Detroit, MI (7%); and Ogdensburg, NY (6%). The quantity of imported salt was about 22 times that of exports. Net salt imports also represented about 23% of U.S. apparent consumption. This indicates the magnitude of the U.S. reliance on salt imports. The majority of imported salt was brought into the country by foreign subsidiaries of major U.S. salt producers. Generally, imported salt can be purchased and delivered to many U.S. customers at prices lower than the comparable domestic product because production costs are lower abroad, currency exchange rates may cause the price of imported salt to be lower than the price of domestic salt, and ocean freight rates are less expensive than overland rail or truck rates.

World Review

Table 13 lists world salt production statistics for 113 nations based on reported and estimated information. In 2010, the total estimated world production increased to about 280 Mt. The United States remained a leading salt-producing country, representing 15% of total world output. China has rapidly increased its production. In 2010, estimated salt production in China was about 63 Mt, making it the leading salt producer in the world, or about 22% of total world output.

Most countries possess some form of salt production capability, with production levels set to meet their own domestic requirements and with additional quantities available for export to other countries. Many developing nations tend to develop their agricultural resources to feed their population first. Utilization of easily extractable mineral resources follows, and salt is one of the first mineral commodities to be mined. Some countries, such as the United States, import a substantial amount of salt to meet total demand requirements because of economic factors, as previously discussed.

Salt Investment S.A. planned to construct a new salt plant at Lake Assal between the cities of Tadjoura and Yoboki in Djibouti to serve the markets in eastern Africa. However, the project was indefinitely suspended in March because of insufficient funds (Feytis, 2010).

Outlook

The U.S. salt industry continued to be a leader in terms of production, consumption, and world trade in salt. Despite the closing and idling of some chlorine plants since 2007 and the Nation's economic problems, the remaining chlorine facilities ran at higher capacity utilization rates, thereby increasing chlorine and caustic soda production as well as salt brine production and consumption. Because the chloralkali industry is energy intensive, any increase in energy prices is likely to reduce chlorine manufacture as well as salt brine usage. Solar salt and vacuum pan salt production and consumption have been constant and are expected to remain stable. U.S. salt production is expected to remain at the 2010 level through 2015. Rock salt production and consumption are heavily dependent on the severity of winter weather. Although the severity of the weather is virtually impossible to accurately forecast far in advance, the supplies of salt, from either domestic or imported sources, are more than adequate to meet any anticipated increase in demand.

Because salt is a relatively low-value commodity, the shipping cost for oceanic, rail, or truck transportation can be an important determining factor when attempting to secure supply sources from either domestic or foreign locations. If energy prices increase, one mode of transportation may be more cost-effective than others. Excluding deicing salt, domestic salt consumption may fluctuate but is likely to continue to increase in accordance with population growth. U.S. total salt production is expected to be an estimated 44 Mt in 2011.

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TABLE 1
SALIENT SALT STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2006	2007	2008	2009	2010
United States:					
Production:[2]					
Brine	19,800	19,700	18,900	17,800	18,500
Rock	16,500	16,800	20,900	20,300	15,800
Solar	3,640	3,650	4,070	3,880	4,830
Vacuum and open pans	4,450	4,420	4,200	4,030	4,100
Total	44,400	44,500	48,000	46,000	43,300
Sold or used by producers:					
Quantity	40,600	45,500	47,400	43,100	43,500
Value	1,310,000	1,520,000	1,690,000	1,750,000	1,690,000
Exports:					
Quantity	973	833	1,030	1,450	595
Value	54,900	59,600	65,900	74,100	69,300
Imports for consumption:					
Quantity	9,490	8,640	13,800	14,700	12,900
Value	163,000	171,000	282,000	337,000	322,000
Consumption:					
Apparent[3]	49,100	53,300	60,200	56,400	55,800
Reported	42,400	53,200	53,100	45,000	48,600
World, production	261,000 [r]	266,000 [r]	276,000 [r]	279,000 [r, e]	280,000 [e]

[e] Estimated. [r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes Puerto Rico.

[3] Sold or used plus imports minus exports.

TABLE 2
U.S. SALT COMPANIES BY PRODUCTION CAPACITY, LOCATION, AND TYPE IN 2010

(Thousand short tons)

Company	Rock	Solar	Vacuum and open pans	Brine
American Rock Salt Co., Hampton Corners, NY	4,500	--	--	--
Cargill, Inc.:				
Akron, OH	--	--	350	(1)
Avery Island, LA	2,700	--	--	(1)
Breaux Bridge, LA	--	--	200	--
Cleveland, OH	4,000	--	--	--
Freedom, OK	--	300	--	--
Lake Point, UT	--	800	--	--
Lansing, NY	2,400	--	--	--
Hutchinson, KS	--	--	450	--
Newark, CA	--	750	150	(1)
St. Clair, MI	--	--	425	--
Watkins Glen, NY	--	--	450	--
Corpus Christi Brine Services, Inc., Benavides, TX	--	--	--	(1)
Detroit Salt Co. LLC, Detroit, MI	1,500	--	--	--
Dow Chemical Co., The:				
Freeport, TX	--	--	--	(1)
Plaquemine, LA	--	--	--	(1)
E.I. duPont de Nemours, New Johnsonville, TN	--	--	230	--
Huck Salt Co., Fallon, NV	20	--	--	--
Hutchinson Salt Co., Hutchinson, KS	750	--	--	--
Independent Salt Co., Kanapolis, KS	750	--	--	--
Key Energy Services, LLC, Hobbs, NM[2]	--	--	--	(1)
Lyons Salt Co., Lyons, KS	600	--	--	--
Moab Salt, Inc., Moab, UT	--	250	--	--
Morton International, Inc.:				
Fairport, OH	2,000	--	--	--
Glendale, AZ	--	150	--	--
Grand Saline, TX	400	--	150	--
Grantsville, UT	--	500	--	--
Manistee, MI	--	--	360	--
Rittman, OH	--	--	600	--
Silver Springs, NY	--	--	375	(1)
South Hutchinson, KS	--	--	350	--
Weeks Island, LA	1,800	--	--	(1)
The Mosaic Co., Hersey, MI[3]	--	--	300	--
New Mexico Salt and Mineral Corp., Loving, NM	--	100	--	--
North American Salt Co.[4]				
Cote Blanche, LA	3,500	--	--	--
Lyons, KS	--	--	425	--
Ogden, UT[5]	--	1,500	--	--
Occidental Chemical Corp., Wichita, KS[6]	--	--	--	(1)
Olin Corp., McIntosh, AL	--	--	--	(1)
PB Energy Storage, Inc.:[7]				
Dale, NY	--	--	--	(1)
Napoleonville, LA	--	--	--	(1)
PPG Industries, Inc.:				
Lake Charles, LA	--	--	--	(1)
New Martinsville, WV	--	--	--	(1)
Redmond Clay & Salt Co., Inc., Redmond, UT	150	--	--	--

See footnotes at end of table.

TABLE 2—Continued
U.S. SALT COMPANIES BY PRODUCTION CAPACITY, LOCATION, AND TYPE IN 2010

(Thousand short tons)

Company	Rock	Solar	Vacuum and open pans	Brine
Searles Valley Minerals, Inc., Trona, CA[8]	--	200	--	--
South Bay Salt Works, Chula Vista, CA[9]	--	125	--	--
Tetra Technologies, Inc., Amboy, CA	--	75	--	--
Texas Brine Corp.:				
Beaumont, TX	--	--	--	(1)
Chacahoula, LA	--	--	--	(1)
Clemville, TX	--	--	--	(1)
Corpus Christi, TX	--	--	--	(1)
Houston, TX	--	--	--	(1)
LaPorte, TX	--	--	--	(1)
Wyoming, NY	--	--	--	(1)
US Salt L.L.C., Watkins Glen, NY	--	--	335	(1)
Union Texas Products Corp., Plaquemine, LA	--	--	--	(1)
United Salt Corp.:				
Baytown, TX	--	--	400	(1)
Carlsbad, NM	--	400	--	--
Hockley, TX	150	--	--	--
Saltville, VA	--	--	200	--
Total production capacity	25,200	5,150	5,750	20,400

-- Zero.

[1] Includes brine for sale and for captive use. Individual brine capacity is assumed to be equal to the quantity of annual brine production, and therefore, considered company proprietary data. Brine producers include those chloralkali producers that produce captive brine and companies that supply brine for chloralkali manufacture, oil field chemicals, etc. Total brine production capacity is the quantity of brine produced for the year.

[2] Formerly Rowland Trucking Co., Inc.; then became Yale E. Key, Inc.

[3] Sells salt to North American Salt Co.

[4] Owned by Compass Minerals, Inc.

[5] Owned by Compass Minerals; operated by Great Salt Lake Minerals Corp.

[6] Formerly Vulcan Chemical Co.

[7] Associated with Texas Brine Corp.

[8] Formerly Pacific Salt and Chemical Co.

[9] Formerly Western Salt Co.

Source: U.S. Geological Survey.

TABLE 3

SALT PRODUCED IN THE UNITED STATES, BY TYPE AND PRODUCT FORM[1]

(Thousand metric tons)

Product form	Vacuum and open pans	Solar	Rock	Brine	Total
2009:					
Bulk	934	2,990	19,600	17,800	41,400
Compressed pellets	1,220	330	XX	XX	1,550
Packaged	1,730	465	522	XX	2,720
Pressed blocks	140	91	156	XX	387
Total	4,030	3,880	20,300	17,800	46,000
2010:					
Bulk	959	3,880	15,500	18,500	38,800
Compressed pellets	1,230	326	XX	XX	1,560
Packaged	1,770	532	330	XX	2,640
Pressed blocks	138	92	67	XX	297
Total	4,100	4,830	15,800	18,500	43,300

XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4

SALT SOLD OR USED IN THE UNITED STATES, BY TYPE AND PRODUCT FORM[1, 2]

(Thousand metric tons and thousand dollars)

Product form	Vacuum and open pans		Solar		Rock		Brine		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
2009:										
Bulk	763	83,200	1,690	63,900	17,600	595,000	17,800	140,000	37,800	882,000
Compressed pellets	1,200	215,000	403	60,700	XX	XX	XX	XX	1,600	276,000
Packaged:										
Less-than-5-pound units	358	NA	1	NA	36	NA	XX	XX	395	XX
More-than-5-pound units	1,510	NA	921	NA	457	NA	XX	XX	2,890	XX
Total	1,870	385,000	922	92,700	493	56,100	XX	XX	3,280	534,000
Pressed blocks:										
For livestock	116	NA	129	NA	151	NA	XX	XX	396	XX
For water treatment	16	NA	1	NA	3	NA	XX	XX	20	XX
Total	132	18,800	130	18,000	154	17,200	XX	XX	416	53,900
Grand total	3,960	702,000	3,140	235,000	18,200	668,000	17,800	140,000	43,100	1,750,000
2010:										
Bulk	750	83,100	3,350	104,000	16,000	542,000	18,500	138,000	38,500	867,000
Compressed pellets	1,230	219,000	399	53,500	XX	XX	XX	XX	1,630	272,000
Packaged:										
Less-than-5-pound units	270	NA	31	NA	6	NA	XX	XX	308	XX
More-than-5-pound units	1,630	NA	717	NA	301	NA	XX	XX	2,640	XX
Total	1,900	396,000	748	71,300	307	34,000	XX	XX	2,950	502,000
Pressed blocks:										
For livestock	128	NA	131	NA	69	NA	XX	XX	328	XX
For water treatment	10	NA	3	NA	1	NA	XX	XX	14	XX
Total	139	19,700	134	14,700	70	11,000	XX	XX	342	45,400
Grand total	4,020	718,000	4,640	244,000	16,300	587,000	18,500	138,000	43,500	1,690,000

NA Not available. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] As reported at salt production locations, the term "sold or used" indicates that some salt, usually salt brine, is not sold but is used for captive purposes by plant or company. Because data do not include salt imported, purchased, and (or) sold from inventory from regional distribution centers, salt sold or used by type may differ from totals shown in tables 5 and 6, which are derived from company totals.

TABLE 5
SALT SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

	2009		2010	
State	Quantity	Value	Quantity	Value
Kansas	2,710	188,000	3,080	194,000
Louisiana	13,200	229,000	14,100	234,000
New York	6,240	426,000	6,460	442,000
Texas	8,910	164,000	9,130	173,000
Utah	2,000	152,000	1,940	100,000
Other Eastern States[3]	8,680	480,000	7,440	437,000
Other Western States[4]	1,380	107,000	1,340	107,000
Total	43,100	1,750,000	43,500	1,690,000
Puerto Rico[e]	45	1,500	45	1,500

[e] Estimated.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The term "sold or used" indicates that some salt, usually salt brine, is not sold but is used for captive purposes by plant or company.

[3] Includes Alabama, Michigan, Ohio, Tennessee, Virginia, and West Virginia.

[4] Includes Arizona, California, Nevada, New Mexico, and Oklahoma.

TABLE 6

DISTRIBUTION OF DOMESTIC AND IMPORTED SALT BY PRODUCERS IN THE UNITED STATES, BY END USE AND TYPE[1,2]

(Thousand metric tons)

End use	Standard industrial classification	Vacuum and open pans		Solar		Rock		Brine		Total[3]	
		2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Chemical:											
Chloralkali producers	2812	82	89	306	299	527	653	15,700	18,100	16,700	19,100
Other chemical	28 (excludes 2812, 2899)	205	232	200	188	832	668	6	1	1,240	1,090
Total		287	321	506	486	1,360	1,320	15,800	18,100	17,900	20,200
Food-processing industry:											
Meat packers	201	205	219	42	33	24	22	--	--	271	275
Dairy	202	120	155	11	11	5	5	--	--	136	171
Canning	2091, 203	157	198	28	32	30	29	--	--	215	258
Baking	205	308	346	3	5	12	13	--	--	324	364
Grain mill products	204 (excludes 2047)	85	96	5	9	9	8	--	--	100	113
Other food processing	206–208, 2047, 2099	493	406	103	93	77	80	1	1	674	580
Total		1,370	1,420	193	184	158	157	1	1	1,720	1,760
General industrial:											
Textiles and dyeing	22	15	19	30	35	3	5	(4)	(4)	48	59
Metal processing	33, 34, 35, 37	4	5	11	11	8	10	(4)	(4)	24	26
Rubber	2822, 30 (excludes 3079)	2	3	(4)	(4)	2	2	(4)	(4)	5	5
Oil	13, 29	62	67	162	133	80	109	11	16	314	325
Pulp and paper	26	9	8	31	32	18	19	--	--	58	59
Tanning and (or) leather	311	1	1	8	11	22	27	--	--	32	39
Other industrial	XX	120	110	87	91	104	216	(4)	(4)	312	418
Total		213	213	329	314	238	388	12	17	792	931
Agricultural:											
Feed retailers and (or) dealers mixers	5159	384	340	381	353	547	637	--	--	1,310	1,330
Feed manufacturers	2048	42	50	84	89	252	285	--	--	377	425
Direct-buying end user	02	3	4	8	7	10	74	--	--	21	85
Total		429	394	472	450	809	996	--	--	1,710	1,840
Water treatment:											
Government (Federal, State, local)	2899	41	47	297	369	68	170	2	5	409	591
Commercial or other	2899	123	63	341	143	128	109	9	7	602	322
Total		164	110	638	512	197	279	11	12	1,010	913
Ice control and (or) stabilization:											
Government (Federal, State, local)	9621	4	4	482	480	13,800	15,300	--	--	14,200	15,800
Commercial or other	XX	39	56	323	275	2,290	2,510	--	--	2,650	2,840
Total		43	60	805	755	16,000	17,900	--	--	16,900	18,700
Distributors:											
Agricultural distribution	5191	72	74	135	127	151	158	--	--	357	359
Grocery wholesalers and (or) retailers	514, 54	493	432	230	215	89	113	--	--	812	761
Institutional wholesalers and end users	58, 70	121	127	64	70	156	118	(4)	(4)	342	315
Water-conditioning distribution	7399	136	143	315	303	16	13	1	1	469	461
U.S. Government resale	9199	(4)	(4)	(4)	(4)	1	(4)	--	--	1	1
Other wholesalers and (or) retailers	5251	769	854	904	968	258	299	(4)	(4)	1,930	2,120
Total		1,590	1,630	1,650	1,680	671	702	2	2	3,910	4,020
Other[5]		50	16	164	3	557	2	292	253	1,060	274
Grand total		4,150	4,160	4,760	4,390	20,000	21,700	16,100	18,400	45,000	48,600

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] The quantity of imports included in the total for each type of salt is the amount reported by the U.S. salt industry, not the quantity reported by the U.S. Census Bureau that appears in tables 1, 9, 10, 11, and 12.

TABLE 6—Continued

DISTRIBUTION OF DOMESTIC AND IMPORTED SALT BY PRODUCERS IN THE UNITED STATES, BY END USE AND TYPE[1, 2]

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[3] Because data include salt imported, produced, and (or) sold from inventory from regional distribution centers, data for salt sold or used by type may differ from totals shown in tables 1, 3, and 4, which are derived from plant reports at salt production locations. Data may differ from totals shown in table 6 because of changes in inventory and (or) incomplete data reporting.

[4] Less than ½ unit.

[5] Includes exports.

TABLE 7

DISTRIBUTION OF DOMESTIC AND IMPORTED EVAPORATED AND ROCK SALT IN THE UNITED STATES, BY DESTINATION[1, 2]

(Thousand metric tons)

	2009				2010			
	Evaporated				Evaporated			
Destination	Vacuum and open pans	Solar	Rock	Total	Vacuum and open pans	Solar	Rock	Total
Alabama	42	7	52	101	41	9	45	95
Alaska	3	2	--	5	3	3	--	6
Arizona	12	110	1	123	12	112	1	125
Arkansas	46	6	56	108	48	6	49	103
California	196	754	6	956	197	548	2	747
Colorado	11	66	10	87	12	85	58	156
Connecticut	16	115	115	245	17	165	151	332
Delaware	11	10	2	23	9	9	3	22
District of Columbia	(3)	33	2	35	(3)	43	9	52
Florida	71	215	4	291	68	198	3	269
Georgia	103	55	36	195	105	74	60	238
Hawaii	13	55	(3)	69	(3)	2	--	2
Idaho	8	39	(3)	48	21	90	(3)	111
Illinois	318	99	2,170	2,590	332	105	2,340	2,780
Indiana	249	121	729	1,100	254	108	923	1,290
Iowa	127	99	434	659	128	102	604	833
Kansas	76	44	1,140	1,260	78	45	859	983
Kentucky	64	7	830	900	72	7	1,160	1,240
Louisiana	66	4	235	306	51	7	216	274
Maine	15	8	148	172	20	6	73	99
Maryland	77	167	20	264	83	161	159	403
Massachusetts	32	48	302	382	32	43	238	313
Michigan	268	42	1,950	2,260	269	38	1,740	2,050
Minnesota	114	223	635	973	120	206	766	1,090
Mississippi	21	4	174	198	22	5	197	224
Missouri	119	71	414	604	112	75	532	719
Montana	1	68	(3)	69	1	64	(3)	65
Nebraska	56	39	23	118	56	43	145	244
Nevada	4	211	19	235	4	226	27	258
New Hampshire	15	108	53	176	15	56	42	113
New Jersey	104	118	112	334	105	107	118	330
New Mexico	20	133	(3)	153	21	192	(3)	213
New York	179	35	3,060	3,280	176	30	2,850	3,050
North Carolina	113	97	74	283	107	108	170	386
North Dakota	16	15	6	37	23	17	8	49
Ohio	426	40	2,090	2,550	422	44	2,710	3,180
Oklahoma	30	27	62	119	30	30	122	182
Oregon	19	39	1	59	19	38	(3)	57
Pennsylvania	172	76	1,920	2,170	181	119	2,180	2,480
Rhode Island	3	227	1	231	4	71	(3)	75
South Carolina	44	9	2	55	45	31	2	78
South Dakota	23	54	9	86	24	51	6	81
Tennessee	123	6	366	495	110	6	539	656
Texas	278	158	209 r	646	293	168	315	776
Utah	14	307	10	331	15	261	10	285
Vermont	5	1	218	225	5	1	202	209
Virginia	88	77	117	281	99	121	276	496
Washington	25	134	1	159	25	124	17	166
West Virginia	20	7	147	173	26	5	421	452

See footnotes at end of table.

TABLE 7—Continued

DISTRIBUTION OF DOMESTIC AND IMPORTED EVAPORATED AND ROCK SALT IN THE UNITED STATES, BY DESTINATION[1, 2]

(Thousand metric tons)

	2009				2010			
	Evaporated				Evaporated			
Destination	Vacuum and open pans	Solar	Rock	Total	Vacuum and open pans	Solar	Rock	Total
Wisconsin	199	158	1,520	1,870	186	155	1,340	1,680
Wyoming	1	47	(3)	49	2	64	(3)	66
Other[4]	86	164	555	804	65	1	14	79
Total[5]	4,150	4,760	20,000	28,900	4,160	4,390	21,700	30,300

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Each salt type includes domestic and imported quantities. Brine is excluded because brine is not shipped out of State.

[3] Less than ½ unit.

[4] Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, and some shipments to unspecified destinations.

[5] Because data include salt imported, purchased, and (or) sold from inventory from regional distribution centers, data for evaporated and rock salt distributed by State may differ from totals shown in tables 1 and 3, which are derived from plant reports at salt production locations. Data may differ from totals shown in table 5 because of changes in inventory and (or) incomplete data reporting.

TABLE 8

AVERAGE VALUE OF SALT, BY PRODUCT FORM AND TYPE[1, 2]

(Dollars per metric ton)

Product form	Vacuum and open pans	Solar	Rock	Brine
2009:				
Bulk	109.05	37.84	33.90	7.85
Compressed pellets	180.00	150.42	XX	XX
Packaged	206.27	100.56	113.74	XX
Average[3]	178.67	72.09	36.08	7.85
Pressed blocks	142.57	138.06	111.79	XX
2010:				
Bulk	110.83	31.09	33.95	7.49
Compressed pellets	177.44	134.10	XX	XX
Packaged	209.19	95.33	110.96	XX
Average[3]	180.08	50.90	35.40	7.49
Pressed blocks	141.56	110.27	158.23	XX

XX Not applicable.

[1] Net selling value, free on board plant, excluding container costs.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Salt value data reported prior to 1984 were an aggregate value per metric ton of bulk, compressed pellets, and packaged salt. For time series continuity, an average of these three types of product forms is presented that is based on the aggregated values and quantities of the product form for each type of salt listed in table 3.

TABLE 9

U.S. EXPORTS OF SALT, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2009		2010	
	Quantity	Value[2]	Quantity	Value[2]
Canada	1,360	50,200	451	40,000
China	1	528	1	797
Colombia	2	341	2	480
Costa Rica	2	362	2	379
Dominican Republic	1	393	1	271
Germany	1	475	1	494
Honduras	1	332	1	233
Japan	3	1,560	3	2,390
Malaysia	3	826	1	378
Mexico	45	7,560	29	6,500
Netherlands	1	704	1	630
Panama	1	133	1	611
Saudi Arabia	4	1,190	8	2,200
United Arab Emirates	1	520	2	609
Other	20	8,980 r	91	13,300
Total	1,450	74,100	595	69,300

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown. (The Harmonized Tariff Schedule of the United States code for salt is 2501.00.0000.)

[2] Free alongside ship value at U.S. ports.

Source: U.S. Census Bureau.

TABLE 10

U.S. EXPORTS OF SALT, BY CUSTOMS DISTRICT[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
District	Quantity	Value[2]	Quantity	Value[2]
Anchorage, AK	(3)	27	(3)	11
Buffalo, NY	30	5,850	76	9,830
Cleveland, OH	1	163	1	136
Detroit, MI	1,200	30,900	191	15,200
El Paso, TX	1	360	2	288
Great Falls, MT	2	644	2	647
Houston, TX	9	3,200	13	5,510
Laredo, TX	36	5,700	22	4,860
Los Angeles, CA	5	3,400	22	3,150
Miami, FL	3	1,410	3	1,190
Mobile, AL	(3)	36	(3)	108
New York, NY	13 r	3,630 r	13	4,390
Nogales, AZ	4	1,270	4	1,030
Norfolk, VA	1	594	2	1,490
Ogdensburg, NY	23	3,940	27	5,220
Pembina, ND	5	1,080	2	628
San Diego, CA	3	251	1	321
San Francisco, CA	3	995	3	821
Seattle, WA	5	1,440	34	2,450
St. Albans, VT	4	710	4	771
Other[4]	102 r	8,500 r	173	11,300
Total	1,450	74,100	595	69,300

r Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown. (The Harmonized Tariff Schedule of the United States code for salt is 2501.00.0000.)

[2] Free alongside ship value at U.S. ports.

[3] Less than ½ unit.

[4] Unknown but assumed to be rail and (or) truck shipments to Canada through various points of departure. Also includes minor shipments through 19 other customs districts.

Source: U.S. Census Bureau.

TABLE 11

U.S. IMPORTS FOR CONSUMPTION OF SALT, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
Country	Quantity	Value[2]	Quantity	Value[2]
Australia	1	175	118	3,590
Bahamas, The	811	12,600	935	16,500
Belgium	4	840	3	887
Brazil	168	3,060	208	4,290
Canada	5,940	131,000	4,240	119,000
Chile	5,170	107,000	5,000	96,100
China	9	1,390	9	2,720
Colombia	5	825	5	992
Cyprus	1	170	4	286
Egypt	291	5,560	398	4,930
France	17	6,790	8	6,800
Germany	9	1,340	6	1,820
India	2	424	2	435
Israel	9	3,840	10	4,620
Italy	70	3,830	68	3,970
Japan	32	558	1	96
Korea, Republic of	1	864	9	1,720
Mexico	1,260	33,400	1,000	28,200
Netherlands	217	6,410	362	11,100
Netherlands Antilles	28	1,010	--	--
New Zealand	(3)	65	(3)	91
Pakistan	2	627	2	946
Peru	408	4,150	406	4,420
South Africa	4	1,300	11	1,310
Spain	65	3,660	44	4,160
Switzerland	44	1,000	(3)	7
Syria	--	--	18	290
Tunisia	54	589	--	--
United Kingdom	67	2,690	9	916
Vietnam	1	184	2	219
Other	1 r	705 r	24	1,840
Total	14,700	337,000	12,900	322,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown. (The Harmonized Tariff Schedule of the United States code for salt is 2501.00.0000.)

[2] Customs value only.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 12

U.S. IMPORTS OF SALT, BY CUSTOMS DISTRICT[1]

(Thousand metric tons and thousand dollars)

District	2009		2010	
	Quantity	Value[2]	Quantity	Value[2]
Anchorage, AK	3	167	16	631
Baltimore, MD	850	27,600	1,690	38,100
Boston, MA	1,630	25,400	1,100	17,300
Buffalo, NY	5	583	122	2,780
Charleston, SC	82	1,610	97	2,710
Chicago, IL	1,170	18,200	912	15,400
Cleveland, OH	246	4,710	271	6,720
Columbia-Snake, OR	145	4,880	187	6,580
Dallas-Fort Worth, TX	(3)	81	1	390
Detroit, MI	1,890	33,300	895	19,700
Duluth, MN	36	3,230	28	2,610
Great Falls, MT	2	226	7	844
Los Angeles, CA	116	4,610	152	6,120
Miami, FL	1	336	1	294
Milwaukee, WI	1,470	20,400	675	12,000
Minneapolis, MN	277	4,110	206	4,140
Mobile, AL	2	2,150	2	2,260
New Orleans, LA	484	13,200	137	3,910
New York, NY	2,600	55,000	2,010	49,300
Norfolk, VA	47	866	240	5,210
Ogdensburg, NY	749	45,000	765	45,200
Pembina, ND	4	795	12	1,660
Philadelphia, PA	1,150	24,400	1,600	31,700
Portland, ME	854	14,400	708	12,300
Providence, RI	235	5,500	350	6,860
San Diego, CA	4	1,150	6	2,010
San Francisco, CA	3	1,230	3	1,370
San Juan, PR	5	883	5	1,050
Savannah, GA	39	2,230	42	1,500
Seattle, WA	119	5,670	44	3,110
St. Albans, VT	2	278	1	131
St. Louis, MO	(3)	79	1	320
Tampa, FL	356	6,900	490	9,830
Wilmington, NC	119	4,490	126	4,360
Other[4]	4 r	3,130 r	4	3,660
Total	14,700	337,000	12,900	322,000

rRevised.

[1] Data are rounded to three significant digits; may not add to totals shown. (The Harmonized Tariff Schedule of the United States code for salt is 2501.00.0000.)

[2] Customs value only.

[3] Less than ½ unit.

[4] Includes imports through six other customs districts.

Source: U.S. Census Bureau.

TABLE 13

SALT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2006	2007	2008	2009[e]	2010[e]
Afghanistan, rock salt[e]	12	12	12	12	12
Albania[e]	25	25	25	25	25
Algeria, brine and sea salt	260	183	202	269 [r, 4]	275 [4]
Angola[e]	35	35	35	35	45
Argentina	1,918	2,358	1,681	1,478 [r, 4]	1,500
Armenia	37	35	37	37	40
Australia, salt and marine salt	11,424	10,855	11,160	10,316 [r, 4]	11,968 [4]
Austria, rock and brine	807	742	874 [r]	1,038 [r, 4]	1,000
Azerbaijan	12	7	8	5 [4]	5
Bahamas, The	1,152	8,823	10,244	10,000	10,000
Bangladesh, marine salt[e, 5]	350	360	360	360 [r]	360
Belarus[e]	1,900	2,000	2,000	2,000	2,000
Bolivia	1	2	1	2 [r, 4]	1 [4]
Bosnia and Herzegovina	416	502	555	556 [r, 4]	663 [4]
Botswana[e, 6]	210	210	210	210	210
Brazil:					
Brine salt	5,122	5,365	5,370 [e]	5,370	5,370
Rock salt	1,624	1,621	1,650 [e]	1,650	1,650
Total	6,746	6,986	7,020 [e]	7,020	7,020
Bulgaria[e]	2,000 [4]	2,000	2,100	1,300 [r]	1,500
Burkina Faso[e]	5	5	5	5	5
Burma, brine salt	84	71	54	133 [4]	97 [4]
Cambodia	59	77	78	-- [r]	--
Canada	14,389	11,862	14,386	14,615 [r, 4]	10,537 [p, 4]
Cape Verde[e]	2	2	2	2	2
Chile	4,580	4,404	6,431	8,382 [4]	8,400
China	56,630	59,760	59,520	58,450 [4]	62,750 [4]
Colombia:					
Marine salt	390	310	386 [r]	357 [r, 4]	375
Rock salt	248	204	245 [r]	255 [r, 4]	260
Total	638	514	632 [r]	612 [r, 4]	635
Costa Rica, marine salt[e]	20	20	--	--	--
Croatia	30	33	33 [e]	32	32
Cuba	266	141	157	266 [r, 4]	260
Denmark, sales[e]	600	600	600	600	60
Djibouti[e]	70 [r]	80 [r]	90 [r]	70 [r]	80
Dominican Republic, marine salt[e]	50	50	50	50	50
Ecuador[e]	75	75	75	75	75
Egypt[e]	1,200 [e]	1,214 [r]	1,879 [r]	2,952 [r, 4]	3,000
El Salvador, marine salt[e]	30	30	30	30	--
Eritrea, marine salt[e]	60	60	60	60	60
Ethiopia, rock salt[5]	218	240	260	281 [4]	290
France, all sources[7]	8,718	6,140	6,100	6,100	6,100
Georgia[e]	30	30	30	30	30

See footnotes at end of table.

TABLE 13—Continued
SALT: WORLD PRODUCTION, BY COUNTRY[1,2]

(Thousand metric tons)

Country[3]	2006	2007	2008	2009[e]	2010[e]
Germany:					
Industrial brines	9,590	7,540 [r]	9,084	9,798 [r,4]	9,800
Rock salt and other	9,663	7,819	6,169 [r]	8,816 [r,4]	8,800
Salt, evaporated, includes marine salt	593	592	580	325 [r,4]	500
Total	19,846	15,951 [r]	15,833 [r]	18,939 [r,4]	19,100
Ghana[e]	123	124	239 [r]	200 [r]	200
Greece[e]	150	150	150	150	150
Guadeloupe[e]	49	49	49	49	49
Guatemala[e]	60 [r]	60 [r]	60 [r]	50	50
Guinea[e]	15	15	15	15	15
Honduras[e]	40	40	40	40	40
Iceland[e]	5	5	5	5	5
India:[e]					
Marine salt	15,500	16,000	16,000	16,500	17,000
Rock salt	3	3	3	3	3
Total	15,500	16,000	16,000	16,500	17,000
Indonesia[e]	700	700	700	720	720
Iran[e, 8]	2,000	2,565 [4]	2,158 [r,4]	2,200 [r]	2,200
Iraq[e]	25	153	109	113 [r]	110
Israel	434	400	421	357 [r,4]	400
Italy, all sources[9]	3,438	2,214	2,200 [e]	2,200	2,200
Jamaica[e]	19	19	19,000 [r]	19,000 [r]	19
Japan[e]	1,166 [4]	1,190	1,200	1,200	1,250
Jordan	29	17	25 [r]	25 [r]	25
Kazakhstan, salt and sodium chloride	417	228	504 [r]	223 [r,4]	229 [4]
Kenya, crude salt[10]	35	12	24	24 [r,4]	24
Korea, North[e]	500	500	500	500	500
Korea, Republic of	286	250	348	382 [r,4]	380
Kuwait[e]	13	14	14	14	14
Laos, rock salt[e]	35	35	35	35	35
Lebanon[e]	20 [r]	20 [r]	20 [r]	20 [r]	20
Libya[e]	40	40	40	40	40
Madagascar[e]	75	75	75	75	75
Mali[e]	6	6	6	6	6
Malta, marine salt[e]	(11)	(11)	(11)	(11)	(11)
Martinique[e]	200	200	200	200	200
Mauritania	(11)	(11)	1	(11) [r,4]	1
Mauritius	9	8	8 [e]	8	8
Mexico	8,371	8,400 [e]	8,809	7,445 [4]	8,431 [4]
Mongolia, mine output	1	1	(11) [r,e]	1 [r]	1
Montenegro, sea water evaporate[e]	5 [4]	20	25	17	17
Morocco, marine and rock salt[e]	250 [4]	250	250	250	250
Mozambique, marine salt[e]	150	110	110	110	110
Namibia, marine salt	604	811	732	782 [r,4]	780
Nepal[e, 12]	--	2	-- [r]	-- [r]	--
Netherlands[e]	5,000	5,000	5,000	5,000	5,000
Netherlands Antilles[e]	500	500	500	500	--
New Zealand[e]	100	100	100	100	100

See footnotes at end of table.

TABLE 13—Continued
SALT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2006	2007	2008	2009[e]	2010[e]
Nicaragua, marine salt[e]	30	30	30	30	30
Niger[e]	1	1	1	1	1
Oman	26 [r]	10	11 [r]	31 [r, 4]	30
Pakistan:[5]					
Marine salt[e]	13	18 [r]	18 [r]	19 [r]	20
Rock salt	2,008	10,153 [r]	10,000 [r]	10,500 [r, 4]	11,000
Total	2,021	10,171 [r]	10,018 [r]	10,500 [r]	11,000
Panama, marine salt[e]	18	18	18	17 [r, 4]	17
Peru	1,253	1,185	1,276	1,567 [r, 4]	1,570
Philippines, marine salt	418	438	510	516 [r, 4]	520
Poland:					
Rock salt	1,130	591	618	989 [r, 4]	990
Recovered from brine	2,899	2,931	2,783 [r]	2,534 [r, 4]	2,530
Total	4,029	3,522	3,401 [r]	3,523 [r, 4]	3,520
Portugal, rock salt	586	591	560	560 [4]	561 [4]
Romania:					
Rock salt	47	51	50 [e]	40 [r]	45
Other	2,574	2,425	2,400 [e]	2,000 [r]	2,000
Total	2,621	2,476	2,450 [e]	2,040 [r]	2,050
Russia	2,900	2,200	2,200 [e]	2,200	2,200
Saudi Arabia	1,752	1,507	1,600	1,600	1,800
Senegal	199	212	241	222 [r, 4]	200
Serbia	30	30	30	29 [4]	29
Slovakia	99	101	99 [r, e]	38 [r, 4]	40
Slovenia[e]	2 [4]	2	2	2	2
South Africa	465	412	416	425 [4]	396 [4]
Spain:					
Marine and other evaporated salt	1,469	1,500	1,500 [e]	1,500	1,500
Rock salt	2,834	2,850	2,850 [e]	2,850	2,850
Total	4,303	4,350	4,350 [e]	4,350	4,350
Sri Lanka[e]	88	70	111 [r]	112 [r]	110
Sudan	12	23	11 [r]	36 [r, 4]	36
Switzerland[e]	300	300	300	300	300
Syria	133	81	81 [e]	78 [4]	80
Tanzania	35	35	26 [r]	27 [r, 4]	28
Thailand:					
Rock salt	1,008	1,135	1,212	1,200	1,200
Other[e]	100	100	100	100	100
Total	1,108	1,235	1,312	1,300	1,300
Tunisia, marine salt	1,127	933	1,063	1,000	1,000
Turkey	4,225 [r]	2,366 [r]	2,472 [r]	3,768 [r, 4]	4,000
Turkmenistan[e]	215	215	215	215	215
Uganda[e]	5	5	5	5	5
Ukraine	5,996	5,548	4,425	5,395 [r, 4]	5,400

See footnotes at end of table.

TABLE 13—Continued
SALT: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2006	2007	2008	2009[e]	2010[e]
United Kingdom:[e]					
Brine salt[13, 14]	2,800	2,800	2,800	2,800	2,800
Rock salt	2,000	2,000	2,000	2,000	2,000
Other salt[14]	1,000	1,000	1,000	1,000	1,000
Total	5,800	5,800	5,800	5,800	5,800
United States, including Puerto Rico:					
United States:					
Brine	19,800	19,700	18,900	17,800 [4]	18,500 [4]
Rock salt	16,500	16,800	20,900	20,300 [4]	15,800 [4]
Solar salt	3,640	3,650	4,070	3,880 [4]	4,830 [4]
Vacuum and open pan	4,450	4,420	4,200	4,030 [4]	4,100 [4]
Puerto Rico[e]	45	45	45	45	45
Total	44,500	44,600	48,100	46,100 [4]	43,300 [4]
Venezuela[e]	350	350	350	350	350
Vietnam	842	857	717 [r]	718 [r]	720
Yemen[e]	47 [r]	53 [r]	61 [r]	65 [r]	65
Grand total	261,000 [r]	266,000 [r]	276,000 [r]	279,000 [r]	280,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 15, 2011.

[3] Salt is produced in many other countries, but quantities are relatively insignificant and reliable production data are not available. Some salt brine production data for manufacture of chlorine, caustic soda, and soda ash are not reported because of incomplete data reporting by many countries.

[4] Reported figure.

[5] Year ending June 30 of that stated.

[6] From natural soda ash production.

[7] Includes marine and rock salt and salt solution.

[8] Year beginning March 21 of that stated.

[9] Includes marine salt.

[10] Production by Magadi Soda Ash Ltd. only.

[11] Less than ½ unit.

[12] Does not include production from Sardinia and Sicily, which is estimated to be 200,000 metric tons per year.

[13] Year ending July 15 of that stated.

[14] Data captioned "Brine salt" for the United Kingdom are the quantities of salt obtained from the evaporation of brine; that captioned "Other salt" are for salt content of brines used for purposes other than production of salt.

SAND AND GRAVEL, CONSTRUCTION

By Wallace P. Bolen

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A total of 795 million metric tons (Mt) of construction sand and gravel was produced in the United States in 2010. This was a decrease of 36 Mt, or 4.4%, from the revised production of 2009. This was the fourth consecutive decrease in annual production and reflected continuing low demand from most building and highway construction markets. The last time there were four consecutive years of decreasing sand and gravel production was during the Great Depression years of 1930 through 1933. The 795 Mt was the lowest production since 1991 when an estimated 708 Mt was produced.

Construction sand and gravel is a traditional basic building material and is one of the earliest materials used by humanity for dwellings and later for outdoor areas such as paths, roadways, and other constructs. Sand and gravel is very accessible and is widely used throughout the United States and the world. As sand and gravel became less available owing to resource restraint or economic conditions in some locales, builders began to crush bedrock to produce a manufactured sand and gravel often referred to as crushed stone. Sand and gravel and crushed stone combined are defined as construction aggregate. The crushed stone industry is reviewed in a separate chapter of the U.S. Geological Survey (USGS) Minerals Yearbook; both of these mineral commodities are usually included in reviews of national, State, or local aggregates industries. All percentages in this report were computed using unrounded data.

The decrease in sand and gravel consumption in 2010 was a reflection of the decrease in the total construction put in place as reported by the U.S. Census Bureau. Total construction declined by about 10% in 2010 compared with that in 2009. Residential and nonresidential construction declined in 2010, 0.8% and 13.9%, respectively. Only 4 of 16 nonresidential categories of construction increased in 2010: conservation and development (20.9%), sewage and waste disposal (4.6%), transportation (2.6%), and highway and street (1.7%) (Davis and others, 2011).

Each year, hundreds of sand and gravel operations are idled, closed, or abandoned, and hundreds more are reactivated or opened. The changing location of construction and highway projects is the major factor in decisions to open, idle, or close operations.

In the United States in 2010, 6,489 construction sand and gravel operations were active (table 6A), 603 operations were reported as idle, and 81 operations either were reported to be closed or were assumed to be permanently shut down. Of the 6,489 active operations, 69 were classified as sales or distribution yards only; a sales yard is defined as a fixed location that receives sand and gravel from a distant source and sells it at the yard. In addition, 76 operations reported that they were either an open pit or a dredge combined with a sales yard that supplemented local production with material from a remote location. A small number of the idle sand and gravel operations reported recycling of asphalt and portland cement concrete but no sand and gravel mining. The 6,489 operations with 7,763 active sand and gravel pits were owned by 4,036 companies or government agencies operating in all 50 States. A review of the data provided by the U.S. Mine Safety and Health Administration (MSHA) revealed 448 newly opened or previously unaccounted for sand and gravel locations that reported at least 500 employee hours of activity during 2010. Information was gathered from these newly recognized operations and included in this report. In 2010, of the 6,489 active operations surveyed, 3,266, or 50%, responded to the USGS canvass. Their total production represented 54% of the 795 Mt produced in 2010. Estimates for operations that did not report were based on prior year's data and MSHA employee hour reports.

According to the U.S. Census Bureau in 2010, sand and gravel exports decreased by 13% to 381,000 metric tons (t), and the value decreased by 2% to $22.6 million compared with the 2009 data (tables 1, 12). For the second straight year, imports of construction sand and gravel decreased, falling 10% in 2010 compared with those in 2009, but the value increased by 45% to $96 million (tables 1, 13). Imports have become a significant source for sand and gravel in some areas of the country, although imports were down 63% since 2005. Domestic apparent consumption of construction sand and gravel, which is defined as production for consumption (sold or used) plus total imports minus total exports, was 797 Mt.

Some information about the production of construction sand and gravel in foreign countries can be found in the U.S. Geological Survey Minerals Yearbook, volume III, Area reports—International. For nonreporting countries, estimates of sand and gravel and crushed stone production can be based on indirect indicators, such as the levels of asphalt and cement consumption.

Production

Of the four major geographic regions, the West again led the Nation in the production of construction sand and gravel in 2010 with 275 Mt, or 35% of the U.S. total (table 2). The West was followed by the Midwest with 235 Mt, or 30%; the South with 194 Mt, or 24%; and the Northeast with 90 Mt, or 11%. Compared with that of 2009, production was essentially unchanged in the Midwest region but decreased in the other regions in 2010.

Of the nine geographic divisions, the Mountain division led the Nation in the production of construction sand and gravel in 2010 with 154 Mt, or 20% of the U.S. total, and was followed by the East North Central with 128 Mt, or 16%, and the Pacific with 121 Mt, or 15% (table 2). Production decreased in eight of the nine divisions compared with that of 2009. Production increased in the West North Central division, gaining 4.6% in

2010 compared with that of 2009. Some of the gains seen here may be related to the spectacular rise in demand for hydraulic fracturing (frac) sands. Increased production of frac sand could result in an increase in byproduct construction grade material which, in turn, may be replacing other aggregate such as crushed stone in some locales. Frac sand activity, both prospecting and new mining, is especially pronounced in Arkansas, Illinois, Minnesota, Texas, and Wisconsin. The USGS is working to clarify the markets supplied by these new frac sand producers. The USGS, MSHA, and State and local agencies continue to refine the tracking of developments within this booming sector.

In 2010, construction sand and gravel was produced in every State (table 3). The leading States with production greater than 25 million metric tons were, in descending order of tonnage, California, Texas, Arizona, Michigan, Minnesota, New York, Ohio, Colorado, Washington, Wisconsin, and Utah. The combined production of these 11 States represented about 52% of the national total. In 2010, production increased in 18 States but decreased in the other 32 States compared with that of 2009, when only 3 States showed production increases. Production increases of greater than 10% were reported in six States—South Carolina (20%), North Dakota (19%), Arkansas (16%), Kansas (12%), Tennessee (10%), and Ohio (10%). Production decreases of 20% or more were reported in four States—Nevada (23%), Delaware (22%), Utah (21%), and Rhode Island (20%).

A review of the production of construction sand and gravel for consumption by size of operation indicates that about 50% of the total production came from 2,027 operations that reported between 100,000 and 499,999 metric tons per year (t/yr); 21% of the construction sand and gravel produced came from 280 operations that reported between 500,000 and 999,999 t/yr; and 12% came from 69 operations that reported 1 million metric tons per year (Mt/yr) production or more. The largest number of operations (4,113, or 63% of total operations) produced less than 100,000 t/yr (16% of the total production) (table 6A).

In 2010, the leading domestic commercial producers of construction sand and gravel were, in descending order of production, Oldcastle Materials, Inc.; CEMEX S.A.B. de C.V.; Vulcan Materials Co.; Lehigh Hanson, Inc.; MDU Resources Group, Inc.; Holcim Group/Aggregate Industries Management, Inc.; Martin Marietta Aggregates; Lafarge North America, Inc.; Granite Construction, Inc.; and Mitsubishi Materials Corp. The combined production of these 10 companies was about 174 Mt, or about 24% of the national total. This is a significant increase compared with 2009 when the top 10 companies produced approximately 20% of the national total. The top 100 producers of construction sand and gravel in the United States in 2010 are listed in table 14.

Consumption

Production of construction sand and gravel reported to the USGS by producers was material that was sold or used by the companies. Stockpiled production is not reported until it is sold or consumed by the producer. Because no consumption surveys are conducted by the USGS for sand and gravel, the sold or used tonnage is assumed to represent the amount produced for domestic consumption and export. Because some of the construction sand and gravel producers did not report a breakdown by end use, their total production was reported under "Unspecified uses, reported." The estimated production of nonrespondents was reported under "Unspecified uses, estimated."

Of the 795 Mt of construction sand and gravel produced in 2010, 60% was used for unspecified uses (tables 4–5). Of the remaining 322 Mt, 43% was used as concrete aggregate; 26% was used for road base and coverings and road stabilization; 12%, for asphaltic concrete aggregate and other bituminous mixtures; 12%, for construction fill; 1% each, for concrete products, plaster and gunite sands, and snow and ice control; and the remaining 4% was used for golf course maintenance; filtration; railroad ballast; road stabilization; roofing granules; and many other miscellaneous uses.

To provide a more accurate estimate of the consumption patterns for construction sand and gravel, the unspecified uses are not included in the above percentages. In any marketing or use-pattern analysis, the total quantities included in "Unspecified uses" may be distributed among the reported use categories by applying the above percentages.

Additional information regarding production or consumption of construction sand and gravel by major uses in each State and State district can be found in the U.S. Geological Survey Minerals Yearbook, volume II, Area reports—Domestic.

Recycling

The USGS collects recycling statistics from construction and demolition companies. Although not all of the companies surveyed responded to the request for information on concrete and asphalt recycling, many did. These data have been combined with recycling data received from aggregate mining companies, both crushed stone and sand and gravel producers. Recycling in this industry generally refers to the crushing, screening, and reuse of asphalt and cement concretes. Aggregates, construction, and demolition companies and related asphalt and ready-mix companies are often involved in construction projects during which they collect and reuse the materials at the site. Sometimes construction companies haul their materials to a recycling location where the asphalt or concrete is processed for reuse. The USGS welcomes additional information on recycling and encourages all construction materials recycling companies to provide statistics on their activities. Companies involved in recycling may contact the author of this report to receive more information on how to report.

Recycled Asphalt.—In 2010, 11 Mt of asphalt concrete valued at $119 million was recycled by aggregate, construction, and demolition companies in 48 States and Puerto Rico (table 10). The leading States, all with more than 500,000 tons of recycled asphalt were, in descending order of tonnage recycled, California, Kansas, North Carolina, Michigan, Illinois, and Pennsylvania. Sand and gravel producers who reported the most recycled asphalt were, in descending order, Stuczynski Trucking and Excavating, Inc.; All American Asphalt Co.; The Lane Construction Corp.; Lyon Sand and Gravel Co.; Matich Corp.; and Holliday Rock Co., Inc.

Recycled Concrete.—In 2010, about 13 Mt of cement concrete valued at $99 million was recycled in 48 States (table 11). The leading States, all with more than 500,000 tons of recycled concrete were, in descending order of tonnage recycled, California, Wisconsin, Michigan, Illinois, Virginia, Colorado, and Minnesota. Sand and gravel producers who reported the most recycled concrete were, in descending order, James Peterson Sons, Inc.; Vulcan Materials, Inc.; Kalin Construction Co., Inc.; Dan Copp Crushing Corp.; and Knopik Crushing, Inc.

Transportation

Information regarding the method of transportation of construction sand and gravel from the pit or processing plant to the first point of sale or use is available for each geographic division and the total United States. Reports regarding the method of transportation were provided by the producers for 263 Mt, or 33% of the total U.S. production of construction sand and gravel in 2010. Of this total, 81% was transported by truck; 3%, by waterway; and less than 1%, by rail (table 7). A significant amount of construction sand and gravel produced (about 15%) was not transported and was used at or near the production site, probably for asphalt or cement concrete production. Because most producers neither keep records of nor report shipping distances or cost per metric ton per mile, transportation cost data are not available.

Prices

Prices discussed in this chapter are synonymous with average unit value and are free on board (f.o.b.) plant, usually the first point of sale or captive use. This does not include transportation from the plant or yard to the consumer. It does include all costs of mining, processing, in-plant transportation, overhead, and profit.

The 2010 average price decreased 3% to $7.31 per metric ton compared with that of 2009. By use, the prices varied from a high of $11.61 per ton for roofing granules to a low of $4.47 per ton for fill (table 4). The largest increases in price were recorded for plaster and gunite sands (19.2%), golf course maintenance (2.9%), and filtration (1.2%). The largest decreases were for roofing granules (43%), asphaltic concrete (11.3%), road stabilization, cement (9.1%), and concrete aggregate (7.7%).

The States having the highest unit value per metric ton were, in descending order, Hawaii ($15.23), Rhode Island ($11.80), Virginia ($11.47), California ($10.83), New Jersey ($10.50), and Maryland ($10.18). The States having the lowest unit value per metric ton were, in ascending order, North Dakota ($3.89), South Dakota ($4.21), South Carolina ($4.25), Minnesota ($4.91), Wyoming ($5.00), and Wisconsin ($5.11). The unit value decreased in 30 States and increased 20 States (table 3). The States having the largest increases in unit value were, in descending order, Hawaii (20%), North Dakota (20%), South Dakota (17%), Indiana (16%), and Michigan (12%). The States having the largest decreases in unit value were, in descending order, Delaware (36%), South Carolina (24%), Minnesota (20%), Maryland (18%), and Alabama (14%).

Foreign Trade

The widespread distribution of domestic sand and gravel deposits and the high cost of transportation limit foreign trade to mostly local transactions across international boundaries. U.S. imports and exports represented less than 1% of domestic consumption.

According to the U.S. Census Bureau, exports of construction sand decreased by about 25% to 59,000 t compared with that of 2009, and the value decreased by about 13% to $16.6 million (table 12). Canada, which was the leading destination, received about 29% of the total sand, followed by the British Virgin Islands (12%), China (8%), the Netherlands (7%), and Mexico (5%). Exports of construction gravel decreased by 11% to 322,000 t compared with those of 2009, but the value increased by about 47% to $6 million. Canada, which was the leading destination, received about 74% of total gravel exports. The average value of the sand and gravel exports in 2010 was $59 per metric ton; this was up from $53 per metric ton in 2009. These values may have been relatively high because some higher grade sand and gravel, such as industrial sand and gravel (especially frac sand), was being misclassified as construction sand and gravel.

In 2010, imports of construction sand and gravel decreased by about 10% to 2.67 Mt, but the value increased by about 45% to $95.9 million (table 13). Canada was the leading source of construction sand and gravel imports, with 82% of the total. Mexico supplied about 8% of the imports, and The Bahamas supplied about 7%. The average unit value of the sand and gravel imports in 2010 was $35.86 per metric ton, up from $22.14 per metric ton in 2009.

Outlook

Consumption of construction sand and gravel in 2011 was expected to be about equal to that of 2010. Continuing weak demand from most construction segments and reduced revenues to and funding for governmental agencies and programs were expected to result in little or no growth in sand and gravel consumption in 2011. Data from the 2011 USGS quarterly survey of U.S. aggregates producers indicate a very slight increase in sales of sand and gravel compared with those of the 2010, based on a limited sample of sand and gravel producers surveyed in the United States.

Mostly owing to weakened demand and increased competition, the industry experienced a contraction in construction sand and gravel prices in 2010, but a slight increase in prices was expected for 2011. Improving but still historically low sales in the housing market and higher fuel costs could keep some upward pressures on sand and gravel prices. Larger price increases are more likely to continue in and near metropolitan areas because, as nearby resources are depleted, more aggregates will be transported from distant sources with the accompanying extra fuel cost.

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TABLE 1

SALIENT U.S. CONSTRUCTION SAND AND GRAVEL STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2006	2007	2008	2009	2010
Sold or used by producers:[2]					
Quantity	1,340,000	1,250,000	1,060,000	831,000 [r]	795,000
Value	8,650,000	8,810,000 [r]	7,890,000 [r]	6,240,000 [r]	5,810,000
Recycle:[3]					
Quantity	15,400	20,100	29,100	28,500 [r]	24,900
Value	111,000	150,000	252,000	264,000 [r]	218,000
Exports:					
Quantity	515	365	392	439	381
Value	24,100	28,700	22,400	23,100	22,600
Imports:					
Quantity	4,960	4,420	5,430	2,980	2,670
Value	94,100	87,700	114,000	66,100	95,900

[r] Revised.

[1] Data are rounded to no more than three significant digits.

[2] Puerto Rico is excluded from all sand and gravel statistics.

[3] Asphalt and portland cement concrete recycled by construction, demolition, and aggregate mining companies.

TABLE 2

CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY GEOGRAPHIC DIVISION [1]

	2009				2010			
Region/division	Quantity (thousand metric tons)	Percentage of total	Value (thousands)	Percentage of total	Quantity (thousand metric tons)	Percentage of total	Value (thousands)	Percentage of total
Northeast:								
New England	37,400	4.5 [r]	$321,000	5.2 [r]	36,100	4.5	$298,000	5.1
Middle Atlantic	56,100	6.8 [r]	497,000	8.0 [r]	54,100	6.8	471,000	8.1
Midwest:								
East North Central	131,000 [r]	15.8	758,000 [r]	12.1 [r]	128,000	16.1	798,000	13.8
West North Central	103,000 [r]	12.4 [r]	554,000 [r]	8.9 [r]	107,000	13.5	557,000	9.6
South:								
South Atlantic	51,900 [r]	6.2 [r]	440,000 [r]	7.1	50,700	6.4	390,000	6.7
East South Central	34,900 [r]	4.2	246,000 [r]	3.9	34,300	4.3	230,000	4.0
West South Central	110,000 [r]	13.2 [r]	859,000 [r]	13.8	109,000	13.8	853,000	14.7
West:								
Mountain	177,000 [r]	21.3 [r]	1,250,000 [r]	20.1	155,000	19.5	1,050,000	18.1
Pacific	130,000	15.6 [r]	1,310,000	21.1 [r]	121,000	15.2	1,160,000	19.9
Total	831,000 [r]	100	6,240,000 [r]	100	795,000	100	5,810,000	100

[r] Revised.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

TABLE 3
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

	2009			2010		
State	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Alabama	10,100 [r]	$65,800 [r]	$6.49	10,100	$56,200	$5.56
Alaska	7,320	55,500	7.58	6,340	52,300	8.24
Arizona	40,200	357,000	8.88	35,200	291,000	8.27
Arkansas	7,780 [r]	60,000 [r]	7.72 [r]	9,050	76,800	8.49
California	79,200	912,000	11.52	74,700	809,000	10.83
Colorado	29,300	217,000	7.42	28,900	209,000	7.22
Connecticut	5,680	60,800	10.70	5,910	55,300	9.35
Delaware	2,080	24,500	11.80	1,620	12,300	7.59
Florida	15,500 [r]	124,000 [r]	8.02 [r]	12,500	98,900	7.93
Georgia	5,260	31,100	5.91	5,120	28,400	5.54
Hawaii	1,130	14,300	12.70	932	14,200	15.23
Idaho	12,900	74,800 [r]	5.82	13,700	78,200	5.71
Illinois	22,500	144,000	6.40	19,400	128,000	6.57
Indiana	18,800	100,000	5.31	18,600	115,000	6.16
Iowa	13,600	87,800 [r]	6.43 [r]	13,800	84,800	6.17
Kansas	8,580	43,300	5.04	9,610	50,300	5.23
Kentucky	6,770	36,000 [r]	5.32 [r]	5,740	30,000	5.24
Louisiana	20,600	205,000	9.92	20,800	190,000	9.14
Maine	9,090	59,300	6.52	7,840	45,100	5.75
Maryland	7,980	99,200	12.43	8,120	82,700	10.18
Massachusetts	9,460	85,600	9.05	9,700	91,400	9.42
Michigan	34,600	176,000	5.10 [r]	33,600	192,000	5.70
Minnesota	31,300 [r]	191,000 [r]	6.12 [r]	32,300	158,000	4.91
Mississippi	12,700	101,000	7.97	12,500	97,100	7.76
Missouri	11,500	71,900	6.26	11,800	73,200	6.21
Montana	11,200	86,000 [r]	7.66	10,100	81,800	8.07
Nebraska	12,900	75,500	5.87	12,500	79,900	6.38
Nevada	19,800 [r]	124,000 [r]	6.25 [r]	15,100	87,500	5.78
New Hampshire	6,930	55,600	8.02	6,390	54,300	8.51
New Jersey	11,100	116,000	10.49	10,000	105,000	10.50
New Mexico	14,100	111,000 [r]	7.86 [r]	11,600	84,400	7.30
New York	31,100	266,000	8.57 [r]	30,600	248,000	8.09
North Carolina	7,570	43,000	5.68	8,130	45,700	5.63
North Dakota	14,300 [r]	46,500 [r]	3.25 [r]	17,000	66,100	3.89
Ohio	27,200	199,000 [r]	7.33 [r]	29,900	232,000	7.75
Oklahoma	11,600	68,200	5.90	10,000	60,500	6.04
Oregon	12,200	102,000	8.39	11,400	93,000	8.15
Pennsylvania	14,000 [r]	115,000 [r]	8.23	13,400	118,000	8.81
Rhode Island	1,820	23,300	12.79	1,450	17,100	11.80
South Carolina	5,900	32,900	5.57	7,100	30,200	4.25
South Dakota	10,600 [r]	38,000 [r]	3.59	10,500	44,300	4.21
Tennessee	5,360	42,800	7.98	5,900	47,000	7.97
Texas	70,000	527,000 [r]	7.53 [r]	69,500	525,000	7.55
Utah	32,400	190,000	5.86	25,700	148,000	5.77
Vermont	4,470	36,700	8.21	4,770	35,200	7.39
Virginia	7,230 [r]	82,200 [r]	11.37 [r]	7,690	88,200	11.47
Washington	29,900	230,000	7.69	27,200	188,000	6.89
West Virginia	410	3,480	8.49	448	3,740	8.35
Wisconsin	28,300 [r]	139,000 [r]	4.92	26,000	133,000	5.11
Wyoming	17,200	92,200	5.36	14,300	71,500	5.00
Total or average	831,000 [r]	6,240,000 [r]	7.51 [r]	795,000	5,810,000	7.31

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4
CONSTRUCTION SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES IN 2010, BY MAJOR USE[1]

Use	Quantity (thousand metric tons)	Value (thousands)	Unit value
Concrete aggregates (including concrete sand)	139,000	$1,090,000	$7.81
Plaster and gunite sands	3,900	36,700	9.42
Concrete products (blocks, bricks, pipe, decorative, etc.)	3,210	30,100	9.37
Asphaltic concrete aggregates and other bituminous mixtures	39,400	352,000	8.93
Road base and coverings	83,000	499,000	6.02
Road stabilization, cement	1,520	11,000	7.29
Road stabilization, lime	785	5,690	7.25
Fill	39,100	175,000	4.47
Snow and ice control	3,590	25,500	7.11
Railroad ballast	614	5,110	8.32
Roofing granules	163	1,890	11.61
Filtration	1,100	9,600	8.73
Golf course maintenance sand	702	7,070	10.07
Other miscellaneous uses	5,310	55,600	10.46
Unspecified:[2]			
Actual	144,000	1,070,000	7.44
Estimated	329,000	2,430,000	7.39
Total or average	795,000	5,810,000	7.31

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Reported and estimated production without a breakdown by end use.

TABLE 5
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2010, BY GEOGRAPHIC DIVISION AND MAJOR USE[1]

(Thousand metric tons and thousand dollars)

Region/division	Concrete aggregates (including concrete sand)		Plaster and gunite sands		Concrete products (blocks, bricks, pipe decorative, etc.)		Asphaltic concrete aggregates and other bituminous mixtures		Road base and coverings[2]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Northeast:										
New England	3,570	31,200	79	1,180	140	958	1,400	17,800	3,810	26,500
Middle Atlantic	7,390	68,400	190	2,040	298	2,880	2,350	24,200	4,570	38,600
Midwest:										
East North Central	24,900	149,000	493	2,200	725	5,960	9,160	64,100	13,700	83,800
West North Central	14,300	86,200	349	2,160	658	6,200	4,940	28,600	21,800	80,600
South:										
South Atlantic	17,900	157,000	548	3,180	623	5,850	1,270	9,580	614	4,380
East South Central	8,390	51,800	49	460	64	636	1,470	14,100	1,300	7,210
West South Central	27,300	224,000	275	3,510	113	1,480	1,380	11,900	5,750	36,500
West:										
Mountain	14,300	115,000	640	5,690	349	3,180	7,520	68,000	22,600	148,000
Pacific	21,200	204,000	1,270	16,300	239	2,960	9,900	113,000	11,200	90,500
Total	139,000	1,090,000	3,890	36,700	3,210	30,100	39,400	351,000	85,300	516,000

	Fill		Snow and ice control		Railroad ballast		Other uses[3]		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Northeast:										
New England	2,180	10,800	579	6,050	51	503	24,300	203,000	36,100	298,000
Middle Atlantic	2,360	12,000	1,120	7,060	17	135	35,800	316,000	54,100	471,000
Midwest:										
East North Central	8,230	35,000	929	4,330	194	1,100	69,100	453,000	128,000	798,000
West North Central	3,690	13,300	314	2,050	15	227	61,500	338,000	107,000	557,000
South:										
South Atlantic	6,120	19,900	65	633	--	--	23,500	190,000	50,700	390,000
East South Central	935	2,590	7	67	--	--	22,100	154,000	34,300	230,000
West South Central	4,350	15,300	11	80	35	576	70,200	560,000	109,000	853,000
West:										
Mountain	5,210	21,400	506	4,910	172	1,360	103,000	684,000	155,000	1,050,000
Pacific	5,990	44,400	59	325	131	1,210	70,700	683,000	121,000	1,160,000
Total	39,100	175,000	3,590	25,500	615	5,110	480,000	3,580,000	795,000	5,810,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes road and other stabilization (cement and lime).

[3] Includes reported and estimated production without a breakdown by end use.

TABLE 6A
CONSTRUCTION SAND AND GRAVEL PRODUCTION IN THE UNITED STATES IN 2010, BY SIZE OF OPERATION

Size range (metric tons)	Number of operations	Percentage of total	Quantity[1] (thousand metric tons)	Percentage of total
Less than 25,000	1,920	29.5	18,700	2.4
25,000 to 49,999	1,030	15.8	34,000	4.3
50,000 to 99,999	1,170	18.0	76,200	9.6
100,000 to 199,999	1,120	17.2	145,000	18.2
200,000 to 299,999	498	7.7	111,000	14.0
300,000 to 399,999	257	4.0	80,800	10.2
400,000 to 499,999	156	2.4	62,800	7.9
500,000 to 599,999	111	1.7	54,900	6.9
600,000 to 699,999	72	1.1	42,200	5.3
700,000 to 799,999	46	0.7	31,300	3.9
800,000 to 899,999	28	0.4	21,800	2.7
900,000 to 999,999	23	0.4	19,600	2.5
1,000,000 to 1,499,999	45	0.7	49,500	6.2
1,500,000 to 1,999,999	13	0.2	20,700	2.6
2,000,000 to 2,499,999	5	0.1	9,690	1.2
2,500,000 and more	6	0.1	16,200	2.0
Total	6,490	100	795,000	100

[1] Data are rounded to no more than three significant digits.

TABLE 6B
CONSTRUCTION SAND AND GRAVEL PRODUCTION IN THE UNITED STATES IN 2010, BY REGION AND SIZE OF OPERATION

Size range (metric tons)	Northeast				Midwest			
	Number of operations	Percentage of total	Quantity[1] (thousand metric tons)	Percentage of total	Number of operations	Percentage of total	Quantity[1] (thousand metric tons)	Percentage of total
Less than 25,000	361	35.4	3,470	3.8	653	28.6	6,440	2.7
25,000 to 49,999	180	17.6	5,890	6.5	391	17.1	13,000	5.5
50,000 to 99,999	183	17.9	11,700	13.0	470	20.6	30,800	13.1
100,000 to 199,999	157	15.4	20,900	23.1	411	18.0	53,000	22.5
200,000 to 299,999	66	6.5	14,900	16.6	158	6.9	35,300	15.0
300,000 to 399,999	30	2.9	9,150	10.2	77	3.4	24,200	10.3
400,000 to 499,999	20	2.0	8,160	9.1	42	1.8	16,800	7.2
500,000 to 599,999	11	1.1	5,410	6.0	28	1.2	13,800	5.9
600,000 to 699,999	5	0.5	2,940	3.3	21	0.9	12,300	5.2
700,000 to 799,999	2	0.2	1,340	1.5	11	0.5	7,460	3.2
800,000 to 899,999	1	0.1	755	0.8	2	0.1	1,550	0.7
900,000 to 999,999	1	0.1	826	0.9	10	0.4	8,490	3.6
1,000,000 to 1,499,999	4	0.4	4,670	5.2	8	0.4	8,500	3.6
1,500,000 to 1,999,999	--	--	--	--	1	--	1,530	0.7
2,000,000 to 2,499,999	--	--	--	--	1	--	1,870	0.8
2,500,000 and more	--	--	--	--	--	--	--	--
Total	1,020	100	90,100	100	2,280	100	235,000	100

Size range (metric tons)	South				West			
	Number of operations	Percentage of total	Quantity[1] (thousand metric tons)	Percentage of total	Number of operations	Percentage of total	Quantity[1] (thousand metric tons)	Percentage of total
Less than 25,000	237	21.8	2,390	1.2	666	31.8	6,410	2.3
25,000 to 49,999	132	12.1	4,460	2.3	323	15.4	10,700	3.9
50,000 to 99,999	166	15.3	10,900	5.6	351	16.7	22,800	8.3
100,000 to 199,999	204	18.8	26,700	13.7	344	16.4	44,500	16.2
200,000 to 299,999	121	11.1	27,400	14.1	153	7.3	33,800	12.3
300,000 to 399,999	68	6.3	21,500	11.1	82	3.9	26,000	9.4
400,000 to 499,999	48	4.4	19,300	9.9	46	2.2	18,600	6.7
500,000 to 599,999	36	3.3	18,000	9.3	36	1.7	17,700	6.4
600,000 to 699,999	20	1.8	11,700	6.0	26	1.2	15,300	5.5
700,000 to 799,999	15	1.4	10,200	5.2	18	0.9	12,300	4.5
800,000 to 899,999	14	1.3	11,000	5.7	11	0.5	8,440	3.1
900,000 to 999,999	8	0.7	6,750	3.5	4	0.2	3,500	1.3
1,000,000 to 1,499,999	12	1.1	13,500	6.9	21	1.0	22,900	8.3
1,500,000 to 1,999,999	5	0.5	7,840	4.0	7	0.3	11,300	4.1
2,000,000 to 2,499,999	--	--	--	--	4	0.2	7,820	2.8
2,500,000 and more	1	0.1	2,790	1.4	5	0.2	13,400	4.9
Total	1,090	100	194,000	100	2,100	100	275,000	100

-- Zero.

[1] Data are rounded to no more than three significant digits.

TABLE 7
CONSTRUCTION SAND AND GRAVEL SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2010, BY GEOGRAPHIC DIVISION AND METHOD OF TRANSPORTATION[1]

(Thousand metric tons)

Region/division	Truck	Rail	Water	Other	Not transported	Not specified	Total
Northeast:							
New England	7,710	--	--	--	1,460	26,900	36,100
Middle Atlantic	14,900	31	307	48	1,450	37,300	54,100
Midwest:							
East North Central	42,500	77	2,750	674	4,300	77,300	128,000
West North Central	30,700	212	705	17	7,650	68,100	107,000
South:							
South Atlantic	24,500	71	150	84	428	25,400	50,700
East South Central	6,120	109	871	47	725	26,400	34,300
West South Central	22,100	530	--	55	7,860	78,800	109,000
West:							
Mountain	31,000	--	--	441	6,990	116,000	155,000
Pacific	33,200	701	2,830	956	7,970	75,000	121,000
Total	213,000	1,730	7,610	2,320	38,800	531,000	795,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 8
NUMBER OF CONSTRUCTION SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 2010, BY GEOGRAPHIC DIVISION

	Mining operations on land					
Region/division	Stationary	Portable	Stationary and portable	No plants or unspecified	Dredging operations	Total active operations
Northeast:						
New England	229	205	40	16	--	490
Middle Atlantic	252	182	43	32	22	531
Midwest:						
East North Central	481	406	75	63	87	1,112
West North Central	427	466	34	74	171	1,172
South:						
South Atlantic	147	76	13	53	71	360
East South Central	113	41	4	11	49	218
West South Central	250	120	14	37	88	509
West:						
Mountain	557	630	65	94	9	1,355
Pacific[1]	391	238	55	38	20	742
Total	2,847	2,364	343	418	517	6,489

-- Zero.

[1] An undetermined number of operations leased from the Bureau of Land Management in Alaska are counted as one operation.

TABLE 9
NUMBER OF CONSTRUCTION SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 2010, BY STATE

State	Mining operations on land				Dredging operations	Total active operations
	Stationary	Portable	Stationary and portable	No plants or unspecified		
Alabama	37	12	--	5	15	69
Alaska[1]	39	19	4	6	3	71
Arizona	88	106	12	4	--	210
Arkansas	36	17	3	--	3	59
California	220	81	21	6	10	338
Colorado	96	126	11	24	5	262
Connecticut	33	21	9	--	--	63
Delaware	4	--	--	4	4	12
Florida	28	10	1	7	15	61
Georgia	21	4	3	--	17	45
Hawaii	13	6	2	--	--	21
Idaho	52	82	4	21	2	161
Illinois	61	18	6	4	27	116
Indiana	67	41	13	1	12	134
Iowa	46	70	6	7	25	154
Kansas	24	47	3	11	34	119
Kentucky	9	3	2	1	9	24
Louisiana	40	14	--	14	40	108
Maine	72	73	10	8	--	163
Maryland	21	5	1	8	3	38
Massachusetts	58	23	3	1	--	85
Michigan	126	145	31	26	14	342
Minnesota	166	168	15	23	5	377
Mississippi	46	18	--	5	15	84
Missouri	35	9	2	--	27	73
Montana	87	71	7	10	--	175
Nebraska	45	22	2	7	80	156
Nevada	57	33	9	8	--	107
New Hampshire	31	41	8	1	--	81
New Jersey	33	7	4	3	9	56
New Mexico	52	50	8	9	--	119
New York	161	148	28	22	6	365
North Carolina	38	21	5	19	14	97
North Dakota	67	66	3	4	--	140
Ohio	100	52	12	6	32	202
Oklahoma	24	17	--	5	29	75
Oregon	39	45	7	13	1	105
Pennsylvania	58	27	11	7	7	110
Rhode Island	7	3	4	1	--	15
South Carolina	12	19	--	2	12	45
South Dakota	44	84	3	22	--	153
Tennessee	21	8	2	--	10	41
Texas	150	72	11	18	16	267
Utah	66	82	13	7	--	168
Vermont	28	44	6	5	--	83
Virginia	20	15	3	13	6	57
Washington	80	87	21	13	6	207
West Virginia	3	2	--	--	--	5
Wisconsin	127	150	13	26	2	318
Wyoming	59	80	1	11	2	153
Total	2,847	2,364	343	418	517	6,489

-- Zero.

[1] An undetermined number of operations leased from the Bureau of Land Management in Alaska are counted as one operation.

TABLE 10
RECYCLED ASPHALT SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

State	2009 Quantity (thousand metric tons)	2009 Value (thousands)	2009 Unit value	2010 Quantity (thousand metric tons)	2010 Value (thousands)	2010 Unit value
Alabama	127 r	$2,520	$19.81 r	133	$2,670	$20.09
Alaska	58 r	1,200	20.77 r	31	650	20.85
Arizona	228 r	1,370	5.99 r	139	1,200	8.62
Arkansas	86 r	908	10.61 r	18	100	5.51
California	1,700	11,600	6.82	1,480	11,400	7.73
Colorado	362	4,050	11.17 r	377	1,590	4.21
Connecticut	125 r	517	4.14 r	141	601	4.26
Delaware	2	35	15.44 r	(3)	5	14.36
Florida	904 r	12,300	13.65 r	77	1,310	17.11
Georgia	197 r	4,280	21.74 r	112	1,970	17.55
Hawaii	73	1,030	14.24 r	--	--	--
Idaho	95 r	587	6.16 r	185	1,190	6.42
Illinois	1,470 r	12,500	8.56 r	828	6,360	7.67
Indiana	225	1,870	8.29 r	138	2,850	20.64
Iowa	27 r	210 r	7.70 r	62	227	3.64
Kansas	1,290	33,200	25.73 r	1,290	32,600	25.34
Kentucky	49	928	19.00 r	65	457	7.00
Louisiana	135 r	757	5.59 r	121	565	4.67
Maine	139	1,130	8.13 r	61	597	9.86
Maryland	146 r	703 r	4.80 r	120	625	5.21
Massachusetts	288 r	2,410	8.38 r	171	1,350	7.90
Michigan	533 r	3,010	5.66 r	883	3,560	4.03
Minnesota	531 r	5,460 r	10.28 r	445	3,550	7.97
Mississippi	137 r	1,780	13.04 r	81	1,570	19.44
Missouri	164	693	4.22 r	31	120	3.88
Montana	9 r	89	10.33 r	50	609	12.22
Nebraska	84 r	1,090	12.91 r	36	535	14.87
Nevada	276 r	1,500	5.45 r	114	638	5.61
New Hampshire	297 r	3,480	11.68 r	301	3,840	12.77
New Jersey	156 r	1,350	8.66 r	63	376	5.95
New Mexico	47 r	262 r	5.57 r	150	749	5.00
New York	382 r	2,840	7.45 r	299	2,160	7.22
North Carolina	875 r	7,850	8.96 r	931	9,610	10.33
North Dakota	42 r	450	10.74 r	23	294	12.59
Ohio	179	1,090	6.10	123	717	5.83
Oklahoma	118	1,570	13.28 r	69	657	9.52
Oregon	217 r	1,580	7.25 r	87	832	9.56
Pennsylvania	1,020	10,100	9.96 r	572	5,110	8.92
Rhode Island	67 r	642 r	9.59 r	20	114	5.62
South Carolina	205 r	4,420	21.54 r	269	3,500	12.99
South Dakota	122 r	752 r	6.18 r	112	1,260	11.26
Tennessee	198 r	1,450	7.34 r	108	747	6.91
Texas	616	4,650	7.54	259	2,000	7.74
Utah	235 r	1,560	6.64 r	37	248	6.71
Vermont	29 r	426 r	14.58 r	55	1,030	18.67
Virginia	233	2,980	12.78 r	275	2,750	10.01
Washington	170 r	948 r	5.59 r	114	767	6.74
West Virginia	--	--	--	--	--	--
Wisconsin	625 r	4,290	6.86 r	352	3,350	9.53
Wyoming	15 r	205	13.94 r	5	33	6.72

See footnoets at end of table.

TABLE 10—Continued

RECYCLED ASPHALT SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1,2]

State	2009 Quantity (thousand metric tons)	2009 Value (thousands)	2009 Unit value	2010 Quantity (thousand metric tons)	2010 Value (thousands)	2010 Unit value
U.S. total or average	15,300 r	$161,000 r	$10.50 r	11,400	$119,000	$10.44
Territory						
Puerto Rico	45	186 r	4.13 r	45	186	4.13
Grand total or average	15,400 r	161,000 r	10.48 r	11,400	119,000	10.41

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Includes construction and demolition companies that do not mine virgin aggregates.

[3] Less then ½ unit.

TABLE 11
RECYCLED CONCRETE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

State	2009			2010		
	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Alabama	51	$377	$7.34 r	(3)	$1	$8.17
Alaska	26 r	124	4.76 r	61	300	4.96
Arizona	69 r	485	7.00 r	25	269	10.71
Arkansas	43 r	193	4.53 r	27	60	2.20
California	1,780 r	14,200 r	7.94 r	2,860	20,900	7.31
Colorado	721 r	5,010 r	6.94 r	582	3,710	6.38
Connecticut	41	328	8.01 r	91	647	7.07
Delaware	7	75	11.02 r	108	598	5.51
Florida	424	4,830	11.40	304	3,400	11.19
Georgia	83	274	3.29 r	99	2,020	20.34
Hawaii	22	215	9.64 r	6	70	12.23
Idaho	32	192	6.05 r	181	1,090	6.00
Illinois	1,180	8,820	7.50 r	836	5,720	6.85
Indiana	139	753 r	5.43 r	114	863	7.54
Iowa	28	239 r	8.39 r	240	1,170	4.88
Kansas	298 r	2,230	7.49 r	275	1,870	6.80
Kentucky	441	4,370	9.92	--	--	--
Louisiana	7	71	10.21 r	39	691	17.75
Maine	39	294	7.53 r	26	198	7.68
Maryland	389	2,030	5.21	294	1,330	4.53
Massachusetts	192	1,610	8.39	142	1,340	9.42
Michigan	1,010	7,180	7.13	1,210	8,030	6.66
Minnesota	782 r	4,890 r	6.25 r	571	4,250	7.44
Mississippi	71	1,550	21.85 r	133	1,990	14.96
Missouri	1	2	4.37 r	37	322	8.76
Montana	20	156 r	7.97 r	34	282	8.34
Nebraska	122	1,120	9.19	128	1,070	8.38
Nevada	94 r	561 r	5.98 r	42	255	6.02
New Hampshire	12	109	8.87 r	8	77	9.07
New Jersey	583	4,730	8.11	195	1,360	6.97
New Mexico	1	2	1.10 r	5	38	7.71
New York	338	2,620	7.74 r	250	2,070	8.28
North Carolina	144 r	1,850	12.86 r	222	2,490	11.22
North Dakota	17	188 r	11.23 r	6	63	11.43
Ohio	337	2,230	6.60 r	349	2,380	6.81
Oklahoma	224	2,940	13.14 r	87	1,050	11.99
Oregon	101	882	8.76 r	70	733	10.44
Pennsylvania	420	2,450	5.83 r	352	1,740	4.94
Rhode Island	127	948 r	7.48 r	84	583	6.91
South Carolina	216	3,630	16.79 r	219	3,310	15.07
South Dakota	110 r	535 r	4.89 r	92	537	5.85
Tennessee	25	149	6.02 r	22	95	4.41
Texas	859	6,750	7.86	34	273	7.96
Utah	224 r	1,890	8.45 r	280	2,340	8.37
Vermont	22	102	4.59 r	4	20	5.38
Virginia	631	5,680	9.01	674	6,010	8.91
Washington	216	1,360 r	6.31 r	307	1,740	5.67
West Virginia	--	--	--	--	--	--
Wisconsin	369	1,940	5.24	1,710	9,160	5.36
Wyoming	58 r	339	5.86 r	14	77	5.53

See footnotes at end of table.

TABLE 11—Continued
RECYCLED CONCRETE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1, 2]

State	2009 Quantity (thousand metric tons)	2009 Value (thousands)	2009 Unit value	2010 Quantity (thousand metric tons)	2010 Value (thousands)	2010 Unit value
U.S. total or average	13,100[r]	$103,000[r]	$7.87[r]	13,400	$98,600	$7.33
Territory						
Puerto Rico	--	--	--	--	--	--
Grand total or average	13,100[r]	103,000[r]	7.87[r]	13,400	98,600	7.33

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Includes construction and demolition companies that do not mine virgin aggregates.

[3] Less then ½ unit.

TABLE 12
U.S. EXPORTS OF CONSTRUCTION SAND AND GRAVEL IN 2010, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country or territory	Sand Quantity	Sand Value, f.a.s.[2]	Gravel Quantity	Gravel Value, f.a.s.[2]
North America:				
Bahamas, The	2	450	8	88
British Virgin Islands	7	78	4	57
Canada	17	2,020	239	3,570
Mexico	3	449	35	915
Other	3	823	1	129
Total	32	3,820	287	4,760
South America:				
Argentina	2	575	--	--
Brazil	2	1,650	(3)	17
Peru	2	342	--	--
Other	3	1,120	1	4
Total	9	3,690	1	21
Europe:				
Denmark	2	1,030	--	--
Germany	1	541	21	764
Netherlands	4	2,260	--	--
United Kingdom	1	565	4	92
Other	2	569	2	93
Total	10	4,960	27	951
Asia:				
China	5	1,450	(3)	22
Korea Republic of	2	342	(3)	8
Other	2	1,880	6	213
Total	9	3,680	6	243
Oceania	(3)	13	1	33
Middle East	1	289	--	--
Africa	(3)	126	(3)	4
Grand total	59	16,600	322	6,010

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship. Value of material at U.S. port of export; based on transaction price, including all charges incurred in placing material alongside ship.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF CONSTRUCTION SAND AND GRAVEL, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
Country or territory	Quantity	Value, c.i.f.[2]	Quantity	Value, c.i.f.[2]
Antigua and Barbuda	4	94	1	16
Australia	2	604	7	819
Bahamas, The	81	1,490	181	2,620
Canada	2,540	47,500	2,190	42,100
China	19	2,580	10	2,810
Germany	(3)	327	1	576
Japan	(3)	154	--	--
Mexico	228	5,680	226	37,000
New Zealand	4	755	5	1,490
Peru	3	683	4	820
Philippines	(3)	70	--	--
Other	95	6,120	48	7,580
Total	2,980	66,100	2,670	95,900

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight. Value of material at U.S. port of entry; based on purchase price and includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 14

THE TOP 100 PRODUCERS OF CONSTRUCTION SAND & GRAVEL IN THE UNITED STATES IN 2010[1]

2010 Rank	2009 Rank	Company
1	1	Oldcastle Materials, Inc.
2	2	CEMEX S.A.B. de C.V.
3	3	Vulcan Materials Co.
4	4	Lehigh Hanson, Inc.
5	5	MDU Resources Group, Inc.
6	8	Bureau of Land Management
7	6	Holcim Group/Aggregate Industries Mgmt., Inc.
8	10	Martin Marietta Aggregates
9	9	Lafarge North America, Inc.
10	12	Granite Construction, Inc.
11	7	Mitsubishi Materials Corp.
12	15	Trinity Industries, Inc.
13	14	Cal Portland Co.
14	11	Fisher Industries
15	13	Clyde Cos., Inc.
16	17	Colas, Inc.
17	16	A. Teichert & Son, Inc.
18	22	Texas Industries, Inc.
19	34	Edw. C. Levy Co.
20	20	Nugent Sand Co.
21	21	Gila River Indian Community
22	19	Fordyce Ltd.
23	24	Lyman-Richey Sand & Gravel Co.
24	18	Las Vegas Paving Corp.
25	29	R.E. Janes Gravel Co.
26	23	York Building Products Co.
27	25	Mathy Construction Co.
28	38	L.G. Everist, Inc.
29	27	Ash Grove Cement Co.
30	32	All American Asphalt Co.
31	37	Lattimore Properties, Inc.
32	48	Multisources Ltd.
33	70	Fred Weber, Inc.
34	44	Dan Gernatt Gravel Products, Inc.
35	30	McMurry Ready Mix Co.
36	—	Summit Materials LLC
37	28	Southern Aggregates LLC
38	50	Irving Materials, Inc.
39	60	U.S. Concrete, Inc.
40	55	Holliday Rock Products Corp.
41	35	Central Specialties, Inc.
42	62	F S T Sand & Gravel, Inc.
43	26	Mulzer Crushed Stone, Inc.
44	41	Miles Sand & Gravel Co.
45	91	Scepaniak WM Construction
46	69	The Olen Corp.
47	64	Salt River Pima-Maricopa Indian Community
48	36	E.R. Jahna Industries, Inc.
49	45	New Enterprise Stone & Lime Co., Inc.
50	86	Clemente Materials, Inc.
51	46	Thelen Sand & Gravel, Inc.
52	51	Sundre Sand & Gravel, Inc.
53	31	Eucon Corp.
54	82	Ennstone Inc.
55	72	Watson Gravel, Inc.
56	—	Lopke F S Contracting Inc.
57	71	Wood Resources Corp.
58	57	Blain Sand & Gravel, Inc.
59	84	Heritage Group
60	67	Boral USA
61	58	Chandler Aggregates, Inc.
62	—	Simpson Construction Materials, LLC
63	47	Dolese Bros. Co.
64	81	Memphis Stone & Gravel Co.
65	74	Wright Materials, Inc.
66	—	Varra Companies Inc.
67	95	A. Lindberg & Sons, Inc.
68	—	Croell Redi-Mix Inc.
69	73	Grand Rapids Gravel Co.
70	39	Quikrete Companies, Inc.
71	—	Welch S&G Inc.
72	54	Snyder Associated Cos., Inc.
73	100	Strata Corp.
74	43	Jobe Materials, LP
75	40	Capital Sand Co., Inc.
76	68	Southwest Rock Products, LLC
77	76	Hilltop Basic Resources, Inc.
78	—	Miller Springs Materials
79	—	Cranesville Aggregates
80	—	O.L. Thompson Construction
81	—	Hammett Gravel Co.
82	—	Mark S&G Co.
83	56	Standard Gravel Co., Inc.
84	90	Roanoke Sand & Gravel Corp.
85	—	Cretex Companies, Inc.
86	52	Amboy Aggregates
87	61	South way Construction Co., Inc.
88	—	Chaney Enterprises Ltd.
89	—	Aggregate Construction Inc.
90	—	Bayou Sand & Gravel LLC
91	—	Wissota Sand & Gravel Co.
92	88	Continental Materials Corp.
93	65	Aggregate Resources, Inc.
94	—	A & S Construction Co.
95	—	Upper Valley Materials Ltd.
96	—	Baldwin Sand & Gravel Co.
97	66	Pacific Aggregates, Inc.
98	63	Rieth-Riley Construction Co., Inc.
99	96	St. Charles Sand Co.
100	—	Higman Sand & Gravel, Inc.

— Not in the top 100 producers of crushed stone in the United States in 2009.

[1] In descending order of tonnage produced.

SELENIUM AND TELLURIUM

By Micheal W. George

Domestic survey data and tables were prepared by Hodan A. Fatah, statistical assistant, and the world production tables were prepared by Glenn J. Wallace, international data coordinator.

In 2010, the average U.S. dealers' prices for commercial-grade selenium and average European price for tellurium increased from those of yearend 2009. Estimated global consumption for both metals also increased. One copper refinery in Texas reported domestic production of primary refined selenium and tellurium. Domestic production of selenium and tellurium remained nearly unchanged in 2010, as did estimates of global production.

Except for two new mines in China, which began production in 2010, selenium and tellurium were recovered as byproducts of nonferrous metal mining, mostly from the anode slimes produced during the electrolytic refining of copper. Selenium and tellurium were also recovered as byproducts from gold, lead, nickel, platinum, and zinc mining.

In a 2006 survey of 56 worldwide electrolytic copper refiners, 52 and 45 plants, respectively, reported selenium and tellurium in their anode slimes. The selenium-containing slimes averaged 7% selenium by weight, with a few containing as much as 25% selenium. Tellurium concentrations were generally lower and averaged 2% (Moats and others, 2007, p. 202–241).

Selenium and tellurium can also be recovered economically from industrial scrap and chemical process residues. Obsolete and damaged photoreceptor drums from plain paper copy machines have been shipped by manufacturers to refineries for recovery of selenium and tellurium metal. The supply of old drums, however, has declined in recent years and now appears to be nearly exhausted.

Production

ASARCO LLC's (Tucson, AZ) copper refinery in Amarillo, TX, was the only U.S. producer of refined selenium and tellurium. One copper refinery produced and exported semirefined material containing 90% selenium plus tellurium for toll-refining in Asia. One copper refiner, which generated selenium- and tellurium-containing slimes that were exported for processing, closed in mid-2010. This left only one other U.S. refinery that generated selenium- and tellurium-containing slimes that were exported for processing in 2010. Most of the selenium and tellurium contained in domestic anode slimes came from copper ores in Arizona and Utah. Domestic production of selenium and tellurium remained relatively unchanged in 2010.

With the higher price of tellurium that persisted during 2007–10 and projected increases in demand, tellurium was increasingly viewed as a valuable byproduct. This helped stimulate exploration for gold-telluride ores, including some early stage projects in the Western United States and Mexico.

Consumption

Selenium.—In 2010, world consumption of selenium was estimated to be higher than 2009 consumption owing to the global economic recovery. Selenium consumption in the glass industry increased because of increased glass production. The estimated global distribution of consumption of selenium by application was metallurgy, 30%; glass manufacturing, 30%; agriculture, 10%; chemicals and pigments, 10%; electronics, 10%; and other, 10%.

The main use for selenium in metallurgical end uses was for the production of electrolytic manganese in China where selenium dioxide (SeO_2) was substituted for sulfur dioxide to reduce the power required to operate electrolytic cells. In 2010, demand for selenium by electrolytic manganese metal producers in China decreased compared with that in 2009 owing to decreased consumption of electrolytic manganese metal by steel producers. About 2 kilograms (kg) of SeO_2 was used per metric ton of electrolytic manganese metal produced.

Metallurgical-grade selenium was used as an additive to cast iron, copper, lead, and steel alloys to improve machinability and casting and forming properties. In the United States, selenium was used as an alloy with bismuth to substitute for lead in plumbing fixtures in response to requirements of the Safe Drinking Water Act Amendments of 1996 (Public Law 104–182) to reduce lead in potable water supplies. In lead-acid storage batteries, the addition of a small amount, about 0.02% by weight, of selenium to low-antimony lead alloys used in the support grids improves the casting and mechanical properties of the alloy.

Selenium was used to decolorize the green tint caused by iron impurities in container glass and other soda-lime silica glass. It was also used as a colorant in art and other glass, such as architectural plate and automobile glass to reduce solar heat transmission through the glass.

Selenium, an essential micronutrient for animal and human health, was added to fertilizer used to grow crops for animal and human consumption. This practice was more common outside the United States, in countries with selenium-poor soils, such as Australia and China.

Chemical and pigment uses of selenium include industrial and pharmaceutical applications. Selenium's principal pharmaceutical use was in shampoo to control dandruff and dermatitis and as an antifungal agent. Cadmium sulfoselenide compounds were used as pigments in ceramics, glazes, paints, and plastics, but because of the relatively high cost and the toxicity of cadmium-based pigments, their use was generally restricted to applications where they were uniquely suited.

Additionally, selenium was used in catalysts to enhance selective oxidation in plating solutions to improve appearance and durability, in blasting caps and gun bluing, in digital x-ray detectors, and in zinc selenide for infrared windows in carbon dioxide lasers.

Although conventional silicon-based cells remained the dominant photovoltaic (PV) technology, thin-film PV cells production continued to increase in 2010 to an estimated 14% of the total market share. Three major types of thin-film PV cells were in commercial production—amorphous silicon and thin-silicon, cadmium telluride (CdTe), and copper indium gallium diselenide (CIGS). Several companies announced plans to expand production of nonsilicon-based solar cells within the next several years. Projections indicated that total thin-film capacity would reach 10 gigawatts (GW) by 2012, with a CdTe capacity of 2.47 GW and a CIGS capacity of 2.11 GW. Recent advancements in CIGS thin films have reduced production costs, improved performance, and reduced the environmental impact of production. In 2010, more than 40 companies were involved in the development of CIGS products; however, very few produced cells commercially (Mehta, 2010).

Tellurium.—World demand for tellurium was estimated to have increased in 2010. The leading use for tellurium was as a metallurgical alloying element. Tellurium was used in steel as a free-machining additive, in copper to improve machinability while not reducing conductivity, in lead to improve resistance to vibration and fatigue, in cast iron to help control the depth of chill, and in malleable iron as a carbide stabilizer. Owing to recent higher tellurium prices, many steel and nonferrous metals producers have reduced consumption and found substitutes for tellurium.

Consumption in chemical, catalysts, and other uses declined owing to the recent increases in price. Tellurium was used as a vulcanizing agent and as an accelerator in the processing of rubber and in catalysts for synthetic fiber production. Other applications included the use of tellurium in blasting caps and as a pigment to produce blue and brown colors in ceramics and glass.

High-purity tellurium was used in alloys for electronics applications, such as thermal imaging, thermoelectric, phase-change memory, and photoelectric devices. Consumption of tellurium in these applications was estimated to have increase in 2010 because of the global economic recovery.

Mercury-cadmium-telluride was used in thermal-imaging devices to convert the raw image into a crisp picture on the screen, for infrared sensors, and for heat-seeking missiles. Semiconducting bismuth telluride was used in thermoelectric cooling devices employed in electronics and consumer products. These devices consist of a series of couples of semiconducting materials which, when connected to a direct current, cause one side of the thermo element to cool while the other side heats. Thermoelectric coolers were most commonly used in electronics and military applications, such as the cooling of infrared detectors, integrated circuits, laser diodes, and medical instrumentation. The devices were also used in high-end automobile car seats to cool seats on hot days. With the global economic recovery, tellurium consumption in thermoelectric consumer goods increased in 2010.

During 2010, the CdTe thin-film PV cell industry increased investments in research and capacity. First Solar Inc. (Phoenix, AZ), the global leader in CdTe production, had plants in Germany, Ohio, and, Malaysia. In 2010, estimated global production for First Solar rose to 1,300 megawatts (MW) of capacity, from 1,230 MW in 2009, owing to expansion at its plant in Malaysia. First Solar reported plans to expand production to 2,100 MW of capacity by 2012 owing to expansions in Germany and construction of new plants in France and Malaysia. Another CdTe manufacturer, Abound Solar Inc. (Fort Collins, CO), with production facilities in Longmont, CO, had a capacity of 200 MW. In December, the company received a $400 million loan guarantee from the U.S. Department of Energy and planned to build a new 640-MW plant in Tipton, ID. Other manufacturers that were planning to produce CdTe solar cells included Calyxo GmbH (Bitterfeld-Wolfen, Germany), PrimeStar Solar Inc. (Arvada, CO), and Solexant Corp. (San Jose, CA). 5N Plus Inc. (Saint-Laurent, Quebec, Canada) was the principal supplier of high-purity cadmium and tellurium to the thin-film industry. The company signed long-term contracts with much of the thin-film industry and has set up solar-cell recycling facilities in Malaysia and the United States (Mehta, 2010; Metal-Pages, 2010a; Runyon, 2010; Wesoff, 2010).

Prices

The Platts Metals Week annual average New York dealer price for selenium was $37.83 per pound in 2010 and was 64% higher than the annual average price in 2009. The price started the year at about $30 per pound, where it remained for the first 2 months of 2010. The price increased to about $39 per pound in March before decreasing to $36 per pound in June. The price rose in September because of increased demand owning to glass and ceramics production in India, and finished the year at $49 per pound (Metal-Pages, 2010c, d).

Metal-Pages published a Rotterdam 99.99%-pure tellurium price, which averaged $221.25 per kilogram in 2010. The price range began the year at $145 to $170 per kilogram and steadily increased until it reached a price range of $230 to $250 per kilogram on May 11. The price range started to decrease in the beginning of July, and by the end of July, the price leveled off at $210 to $230 per kilogram. The price range increased to $220 to $250 per kilogram on October 12 before it jumped to $275 to $300 per kilogram on November 25. The price range decreased slightly on December 23 to $265 to $300 per kilogram.

Foreign Trade

Exports of selenium materials in 2010 increased by 49% compared with those of 2009. In descending order, Germany, Hong Kong, the Republic of Korea, China, Australia, and Japan accounted for 82% of selenium exports in 2010 (table 2). The annual average value of exports in 2010 of $17.41 per kilogram was higher than the $16.79 per kilogram in 2009.

In 2010, imports of selenium (SeO_2 and selenium unwrought and waste and scrap) increased by 82% to 480 metric tons (t) compared with 2009 imports (table 3). China, Belgium, the Philippines, Japan, Germany, Mexico, and Canada, in descending order, accounted for 94% of the imports of selenium metal and SeO_2 into the United States in 2010.

Imports of unwrought tellurium and tellurium waste and scrap decreased by 50% in 2010 compared with imports in 2009. The leading suppliers, in descending order, Canada, the Philippines, China, and Belgium, accounted for 97% of the total imports of tellurium metal into the United States (table 5). The average value of imports in 2010 was $217.14 per kilogram of tellurium, which was the alltime high.

In 2010, tellurium exports rose to 59 t, from 8 t in 2009. The main destinations were, in descending order, China, the United Kingdom, Belgium, the Philippines, Hong Kong, and Canada, which accounted for 97% of total tellurium exports (table 4). The average value of exports of tellurium in 2010 was $91.44 per kilogram, which was lower than the 2009 value of $148.33 per kilogram because of the export of low-value and low-grade tellurium material, such as waste and scrap, because of the higher price of tellurium.

World Review

Global selenium and tellurium output cannot be easily determined because not all companies or countries report production and because trade in scrap and semirefined products may be included in selenium trade data.

In 2010, refinery production of selenium, based on data from a select few countries, decreased 3% to 2,120 t (table 6). Average world production was estimated to be about 3,000 to 3,500 metric tons per year (t/yr) of selenium and 450 to 500 t/yr of tellurium. Based on global copper refinery data (Moats and others, 2007, p. 202–241), the U.S. Geological Survey estimated that copper anode slimes in 2006 contained 4,600 t and 1,200 t, respectively, of selenium and tellurium.

Belgium.—In 2010, Umicore Precious Metals Refining received 350,000 t/yr of mixed metal material to recycle. The company has a capacity to produce 600 t/yr of selenium and 150 t/yr of tellurium powder (Metal-Pages, 2010b).

Canada.—In 2010, the Canadian Government estimated selenium production to be 79 t, down by 40% compared with revised 2009 production. Tellurium production in Canada was 8 t, down by 50% from that of 2009 (Natural Resources Canada, 2011).

China.—In 2010, China was the leading consumer of selenium, with about 40% to 50% of world consumption, as well as a significant producer. China still depended, however, on imports for most of its selenium needs and imported 1,570 t of selenium products in 2010, a slight increase compared with 2009 imports. China's consumption of selenium was estimated to be 1,500 to 2,000 t/yr, with electrolytic manganese production consuming about 1,000 t/yr and ceramics and glassmaking consuming 350 t/yr combined. In 2010, the country had about 500 t/yr of refined selenium capacity, but this was expected to increase to 600 t/yr when new production techniques were implemented (Roskill's Letters from Japan, 2010a, b; Metal-Pages, 2011).

Apollo Solar Energy, Inc. (Chengdu, Sichuan Province) started up two mines where the main product was tellurium. Production from these mines was expected to supply 60% to 70% of the company's needs for tellurium to produce solar cells. The company announced that the indicated and inferred resources for the Dashuigou project were 30,200 t of ore grading 1.09% tellurium and containing 328 t of tellurium, and the Majiagou project resources were 13,400 t of ore grading 3.26% tellurium and containing 437 t of tellurium (Metal-Pages, 2009; Apollo Solar Energy, Inc., 2010, p. 18).

Japan.—The major producers of selenium and tellurium were Mitsubishi Materials Corp.; Mitsui Metal Mining and Smelting Co., Ltd.; Nippon Rare Metals, Inc.; Pan Pacific Copper Co., Ltd.; Shinko Chemicals Co., Ltd.; and Sumitomo Metal Mining Co., Ltd. In 2010, selenium production was estimated to be 754 t, an increase of 5% compared with revised 2009 production. In 2010, stockpiles of selenium dropped to 40 t from 160 t in 2009. Most Japanese production of tellurium was as a byproduct of copper refining, and the majority was exported. Domestic consumption was dominated by Japanese steel industry (Roskill's Letters from Japan, 2010a, b; 2011).

Mexico.—Southern Copper Corp. (Phoenix, AZ) operated the La Caridad precious metals plant in the State of Sonora, which had a capacity to produce 342 kilograms per day of selenium. Production in 2010 likely declined owing to lower production of refined copper (Southern Copper Corp., 2011, p. 37).

Peru.—Southern Copper produced selenium at its Ilo refinery in the southern Peru. In 2010, selenium production was 59,000 kg, up by 5% compared with that of 2009 (Southern Copper Corp., 2011, p. 47).

Outlook

The supply of selenium and tellurium is directly affected by the production of the principal product from which it is derived—copper—and to a lesser extent, by the production of gold, lead, nickel, or zinc produced from sulfide ores. Since global refined production of copper was projected to increase, production of selenium and tellurium also was expected to increase in 2011. Increased recovery rates at copper refiners could increase selenium and tellurium supply, and longer term investments in gold-tellurium deposits and other sources of tellurium, such as the tellurium mines in China, could boost the global rate of tellurium production above the growth in copper production. Although increased environmental regulation and prices have encouraged the recycling of electronic scrap, recovery of selenium and tellurium has been declining during the past several years owing to the reduction in available scrap selenium- and tellurium-based copier drums. However, many high-grade tellurium producers and users were recovering much of the manufacturing scrap from the production of consumable goods. Also, solar-cell recycling plants have been built in the United States and around the world that would capture selenium and tellurium from CIGS and CdTe cells.

Demand from China for selenium was expected to increase owing to increased demand from the electrolytic manganese metal industry. Global demand for selenium from glass and solar cell manufacturers will probably increase, as there are few substitutes in glass manufacturing, and the expansion of solar cell production was expected to continue.

In 2011, tellurium consumption was expected to increase, chiefly owing to increased electronics and solar-cell production. As the technologies for these uses, especially solar cells and thermoelectronics, continue to advance, manufacturers likely will find ways to reduce unit consumption through efficiency, recycling, and thrifting. Consumption for metallurgical alloying and chemicals was expected to decrease as the cost of tellurium continues to rise; producers of low-value products were expected to find substitutes.

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TABLE 1

SALIENT SELENIUM AND TELLURIUM STATISTICS[1]

(Kilograms, contained metal, unless otherwise specified)

Selenium:	2006	2007	2008	2009	2010
United States:					
Production, primary refined	W	W	W	W	W
Exports	204,000 [r]	592,000 [r]	562,000 [r]	618,000 [r]	919,000
Imports for consumption	409,000	544,000	519,000	263,000	480,000
Dealers' price, average, commercial grade,[2] dollars per pound	24.57	33.08	32.29	23.07	37.83
World, refinery production	2,090,000 [r]	2,200,000 [r]	2,180,000 [r]	2,190,000 [r]	2,120,000 [e]
Tellurium, United States:					
Production, primary refined	W	W	W	W	W
Exports	3,550	15,100	50,000	8,130	59,000
Imports for consumption	14,100	19,800	46,200	38,100	18,900
Price, commercial grade,[3] dollars per kilogram	60.00	110.00	175.00	130.00	221.25

[e] Estimated, [r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Source: Platts Metals Week.

[3] For 2006–08, average yearend price published by Mining Journal for United Kingdom lump and powder, 99.95% tellurium. On September 14, 2009, this price was discontinued. For 2009, the price was the average September 14 price published by Mining Journal for United Kingdom lump and powder, 99.95% tellurium. The 2010 price was 99.99% Tellurium IWH Rotterdam annual average price as reported by Metal-Pages.com.

TABLE 2
U.S. EXPORTS OF SELENIUM[1]

Country	2009		2010	
	Quantity (kilograms, contained Se)	Value	Quantity (kilograms, contained Se)	Value
Argentina	5,540	$85,800	6,960	$108,000
Australia	93,200	1,440,000	99,800	2,060,000
Belgium	12,000	138,000	502	7,780
Canada	15,600 r	440,000	26,900	783,000
Chile	2,170	33,700	--	--
China	141,000	2,410,000	101,000	1,530,000
Colombia	3,970	67,500	8,680	99,100
Costa Rica	550	2,940	--	--
France	--	--	263	4,070
Germany	64,200	1,090,000	212,000	3,290,000
Hong Kong	151,000	2,650,000	160,000	3,280,000
India	--	--	5,500	85,300
Indonesia	3,470	51,900	18,500	287,000
Israel	--	--	750	11,600
Italy	245	3,800	--	--
Japan	2,530	39,300	72,600	1,130,000
Korea, Republic of	51,100	832,000	106,000	1,890,000
Malaysia	170	2,630	--	--
Mexico	10,400	172,000	36,100	569,000
Netherlands	--	--	120	3,110
Panama	1,680	26,000	--	--
Peru	841	13,000	6,490	99,100
Philippines	--	--	2,370	40,400
Singapore	6,120	44,800	15,600	121,000
South Africa	141	9,280	11,800	167,000
Sweden	38,700	626,000	--	--
Taiwan	--	--	8,220	133,000
United Kingdom	1,610	25,000	1,950	41,000
Venezuela	11,100	169,000	15,800	246,000
Vietnam	--	--	924	14,300
Total	618,000 r	10,400,000	919,000	16,000,000

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 3
U.S. IMPORTS FOR CONSUMPTION OF SELENIUM[1]

Class and country	2009 Quantity (kilograms, contained Se)	2009 Value	2010 Quantity (kilograms, contained Se)	2010 Value
Selenium:				
Belgium	39,100	$1,760,000	89,200	$7,110,000
Canada	43,000	1,950,000	38,200	2,810,000
China	18,000	1,090,000	96,400	4,580,000
Germany	43,900	2,320,000	47,100	3,660,000
Hong Kong	1	3,400	2,000	148,000
India	--	--	5	7,250
Japan	19,600	846,000	59,400	4,550,000
Korea, Republic of	--	--	6,000	429,000
Mexico	42,000	1,680,000	38,700	2,500,000
Netherlands	1,280	54,000	1	6,550
Peru	1,800	64,000	--	--
Philippines	35,600	2,080,000	72,500	6,660,000
United Kingdom	15,700	897,000	21,400	1,640,000
Total	260,000	12,700,000	471,000	34,100,000
Selenium dioxide:[2]				
China	--	--	6,290	401,000
Germany	3,230	197,000	1,620	159,000
Japan	193	12,700	1,260	65,800
Total	3,420	210,000	9,170	626,000
Grand total	263,000	13,000,000	480,000	34,700,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Selenium content calculated as 71% of gross weight of material.

Source: U.S. Census Bureau.

TABLE 4
U.S. EXPORTS OF TELLURIUM[1]

Country	2009 Quantity (kilograms, contained Te)	2009 Value	2010 Quantity (kilograms, contained Te)	2010 Value
Australia	--	--	489	$73,400
Belgium	213	$32,000	6,540	1,340,000
Brazil	92	16,400	90	14,400
Canada	157	7,540	906	833,000
China	2,010	301,000	25,800	1,850,000
France	13	7,760	243	121,000
Germany	2,250	476,000	746	245,000
Hong Kong	1,880	161,000	1,930	289,000
India	95	13,100	--	--
Japan	--	--	48	9,020
Korea, Republic of	--	--	10	10,600
Mexico	--	--	29	5,230
Philippines	--	--	6,320	185,000
Taiwan	556	81,000	--	--
United Kingdom	878	110,000	15,900	423,000
Total	8,130	1,210,000	59,000	5,400,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF TELLURIUM[1]

	2009		2010	
Country	Quantity (kilograms, contained Te)	Value	Quantity (kilograms, contained Te)	Value
Belgium	3,220	$227,000	2,050	$440,000
Canada	18,300	4,030,000	26,900	6,100,000
China	39,400	3,310,000	4,050	1,150,000
Germany	12	7,880	33	11,900
Japan	3,020	485,000	31	28,200
Kazakhstan	200	36,000	--	--
Korea, Republic of	500	198,000	--	--
Mexico	2,790	377,000	--	--
Netherlands	52	3,500	--	--
Phillippines	10,200	1,890,000	7,520	1,090,000
Russia	5,780	691,000	680	156,000
Ukraine	--	--	3	11,000
United Kingdom	390	69,000	331	49,400
Total	84,000	11,300,000	41,600	9,040,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 6
SELENIUM: WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Kilograms, contained selenium)

Country[3]	2006	2007	2008[e]	2009[e]	2010[e]
Belgium[e]	200,000	200,000	200,000	200,000	200,000
Canada[4]	106,000	144,000	156,000 [5]	173,000 [5]	79,000 [p]
Chile[e]	74,000	70,000	78,000	90,000 [r]	90,000
Finland[e]	62,000	60,000	64,730 [5]	65,000	60,000
Germany[e]	650,000 [r]	650,000 [r]	650,000 [r]	650,000 [r]	650,000
India[e, 6]	13,000	14,000	14,000	15,000	15,000
Japan	730,100	805,600	754,000 [5]	722,200 [r, 5]	753,300 [5]
Peru	49,800	45,000	45,000	45,000	45,000
Philippines[e]	65,000	65,000	65,000	65,000	65,000
Russia[e]	110,000	120,000	130,000	140,000	140,000
Serbia[e]	7,500	7,500	7,500	7,500	7,500
Sweden[e]	20,000	20,000	20,000	20,000	20,000
United States	W	W	W	W	W
Total	2,090,000 [r]	2,200,000 [r]	2,180,000 [r]	2,190,000 [r]	2,120,000

[e] Estimated. [p] Preliminary. [r] Revised. W Withheld to avoid disclosing company proprietary data; not included in total.

[1] World totals and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[2] Insofar as possible, data relate to refinery output only; thus, countries that produced selenium contained in copper ores, copper concentrates, blister copper, and (or) refinery residues but did not recover refined selenium from these materials indigenously were excluded to avoid double counting. Table includes data available through June 7, 2011.

[3] In addition to the countries listed, Australia, China, Iran, Kazakhstan, Mexico, Poland, and Uzbekistan produced refined selenium, but output is not reported, available information is inadequate for formulation of reliable estimates output levels. Australia is known to produce selenium in intermediate metallurgical products and has facilities to produce elemental selenium. In addition to having facilities for processing imported anode slimes for the recovery of selenium and precious metals, the United States has facilities for processing selenium scrap.

[4] Excludes selenium intermediates exported for refining.

[5] Reported figure.

[6] Data are for Indian fiscal year beginning April 1 of year stated.

TABLE 7
TELLURIUM: WORLD REFINERY PRODUCTION, BY COUNTRY[1,2]

(Kilograms, contained tellurium)

Country[3]	2006	2007	2008[e]	2009[e]	2010[e]
Canada[4]	10,000	14,000	19,000	16,000	8,000 [p]
Japan	35,000	41,000	46,500 [r]	49,200 [r]	51,000
Peru	37,000	35,000	28,000	30,000	30,000
Russia[e]	34,000	34,000	34,000	34,000	34,000
United States	W	W	W	W	W

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data.

[1] Estimated data are rounded to no more than three significant digits.

[2] Insofar as possible, data relate to refinery output only; thus, countries that produced tellurium contained in copper ores, copper concentrates, blister copper, and (or) refinery residues but did not recover refined tellurium are excluded to avoid double counting. Table is not totaled because of exclusion of data from major world producers.

[3] Australia, Belgium, Chile, China, Colombia, Germany, Mexico, the Philippines, Poland, and some countries of the Commonwealth of Independent States, including Kazakhstan, are known to produce refined tellurium, but output is not reported; available information is inadequate for formulation of reliable estimates of output levels.

[4] Excludes tellurium intermediates exported for refining.

SILICA

By Thomas P. Dolley

Domestic survey data and tables were prepared by Annie Hwang, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

Four silica categories are covered in this report—industrial sand and gravel, quartz crystal (a form of crystalline silica), special silica stone products, and tripoli. Most of the stone covered in the special silica stone products section is novaculite. The section on tripoli includes tripoli and other fine-grained, porous silica materials, such as rottenstone, that have similar properties and end uses. Certain silica and silicate materials, such as diatomite and pumice, are covered in other chapters of the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals. Trade data in this report are from the U.S. Census Bureau. All percentages were computed using unrounded data.

Industrial Sand and Gravel

Total industrial sand and gravel production in the United States increased to 29.9 million metric tons (Mt) in 2010 from 24.6 Mt in 2009 (table 1). After the steep decline from 2008 to 2009, industrial sand production increased by 22%, and industrial gravel production, by 3%, compared with that of 2009. During the year, the value of production exceeded $1 billion—the first time in the history of the USGS voluntary survey of U.S. producers of industrial sand and gravel. Estimated world production in 2010 was 121 Mt, a 6% increase compared with 2009 production (table 10).

Industrial sand and gravel, often called "silica," "silica sand," and "quartz sand," includes sands and gravels with high silicon dioxide (SiO_2) content. Some examples of end uses for these sands and gravels are in abrasives, filtration, foundry, glassmaking, hydraulic fracturing (frac), and silicon metal applications. The specifications for each use differ, but silica resources for most uses are abundant. In almost all cases, silica mining uses open pit or dredging methods with standard mining equipment. Except for temporarily disturbing the immediate area while operations are active, sand and gravel mining usually has limited environmental impact.

The production increase for silica sand in 2010 was largely attributable to surging demand for hydraulic fracturing sand. The increased demand for hydraulic fracturing sand was the result of ongoing and increased exploration and production of natural gas from various underground shale formations throughout the United States. Additionally, most major silica sand producers had production capacity increases for hydraulic fracturing sand along with the addition of newer hydraulic fracturing sand operations to the USGS voluntary survey of U.S. producers. Increased demand was noted for uses such as sand for abrasives, chemicals, fiberglass, flat glass, hydraulic fracturing, well packing and cementing, and whole grain silica. Production of the remaining end uses for silica sand in 2010 either remained static or experienced declines compared with those of the previous year. Demand for silica gravel increased slightly for all end uses.

Legislation and Government Programs.—Effective January 24, 2008, the Occupational Safety and Health Administration (OSHA) announced a new National Emphasis Program to target worksites where employees are at risk for silicosis. Other elements included in the directive are an evaluation procedure for recording reductions of employee exposures to silica, as well as information on outreach programs, partnerships and alliances with employers to share resources, and training to reduce employee exposure (Occupational Safety and Health Administration, 2008, p. 10).

One of the most important issues affecting the industrial minerals industry in recent years has been the potential effect of crystalline silica on human health. Central to the ongoing and often heated debate have been the understanding of the regulations and the implementation of the measurements and actions taken to mitigate exposure to crystalline silica and appreciation of the impact of such exposure on the future of many industries (Industrial Minerals, 1998). OSHA created a permissible exposure limit that stipulated the maximum amount of crystalline silica to which workers may be safely exposed during an 8-hour work shift (29 CFR §§1926.55 and 1910.1000). OSHA also established guidelines and training for the proper handling of crystalline silica (Occupational Safety and Health Administration, 2002).

Production.—Domestic production data for industrial sand and gravel were developed by the USGS from a voluntary survey of U.S. producers. The USGS canvassed 68 producers with 116 operations known to produce industrial sand and gravel. Of the 116 surveyed operations, 113 (97%) were active, and 3 were idle. The USGS received responses from 68 operations, and their combined production represented 77% of the U.S. total. Production for the 48 nonrespondents was estimated, primarily on the basis of previously reported information, supplemented with worker-hour reports from the Mine Safety and Health Administration (MSHA) and information from State agencies.

The Midwest (East North Central and West North Central divisions) led the Nation with 49% of the 29.9 Mt of industrial sand and gravel produced in the United States, followed by the South (South Atlantic, East South Central, and West South Central divisions) with 39%, the West (Pacific and Mountain divisions) with 7%, and the Northeast (New England and Middle Atlantic) with 5% (table 2).

The leading producing States were, in descending order, Illinois, Texas, Wisconsin, Minnesota, Oklahoma, North Carolina, California, and Michigan (table 3). Their combined production represented 64% of the national total. States for which data have been withheld in table 3 are not included among the leading producers.

Of the total industrial sand and gravel produced, 88% was produced by 49 operations, each with production of 200,000 metric tons per year (t/yr) or more (table 4). The 10 leading producers of industrial sand and gravel were, in descending order, Unimin Corp.; U.S. Silica Co.; Fairmount Minerals Ltd.; Preferred Rocks of Genoa, LLC; Carmeuse Lime and Stone; Badger Mining Corp.; EOG Resources Inc.; Pattison Sand Co., LLC; Manley Bros. of Indiana, Inc.; and Little Six Corp. Their combined production represented 86% of the U.S. total.

In the past several years, as conventional natural gas sources in the United States have become less abundant, drilling companies have turned to deep natural gas and shale gas. Because of this, demand for hydraulic fracturing sand has increased dramatically, and the United States is the largest market for hydraulic fracturing sand. In response to this demand, Unimin Corp. was expanding capacity at its Arkansas operation for hydraulic fracturing sand and U.S. Silica Co. was increasing capacity for hydraulic fracturing sand at its Illinois operation. Additionally, Preferred Rocks of Genoa, LLC was upgrading its hydraulic fracturing sand capacity after entering the market in 2008 (Industrial Minerals, 2010).

Consumption.—Industrial sand and gravel production reported by producers to the USGS was material used by the producing companies or sold to their customers. Stockpiled material is not reported until consumed or sold. Of the 29.9 Mt of industrial sand and gravel sold or used, 41% was consumed as hydraulic fracturing sand and sand for well packing and cementing, and 26% as glassmaking sand (table 6). Foundry uses consumed 11% of industrial sand and gravel consumption. Other important uses were other whole grain silica (6%) and whole grain fillers and building products (6%).

Minable deposits of industrial sand and gravel occur throughout the United States, and mining companies are located near markets that have traditionally been in the Eastern United States. In some cases, consuming industries are specifically located near a silica resource. The automotive industry was originally located in the Midwest near clay, coal, iron, and silica resources. Therefore, foundry sands have been widely produced in Illinois, Indiana, Michigan, Ohio, and other Midwestern States. In 2010, 78% of foundry sand was produced in the Midwest.

Producers of industrial sand and gravel were asked to provide statistics on the destination of silica produced at their operations. The producers were asked to list only the quantity of shipments (no value data were collected in this section of the questionnaire) and the State or other location to which the material was shipped for consumption. The States that received the most industrial sand and gravel were Texas (15%), Illinois (5%), Pennsylvania (4%), California (4%), Oklahoma (3%), and Indiana (2%). Producers reported sending 174,000 t of silica to Mexico and 322,000 t to Canada (table 7). Because some producers did not provide this information, their data were estimated or assigned to the "Destination unknown" category. In 2010, 30% of industrial sand and gravel shipped by producers was assigned to that category.

The share of silica sold for all types of glassmaking increased slightly compared with that of 2009. In 2010, sales to container glass manufacturers declined by about 9% compared with those in 2009. On average, in the container glassmaking industry, silica accounts for 60% of raw materials used (Industrial Minerals, 2004). The amount of unground silica sand consumed for fiberglass production increased by 18% compared with that of 2009.

In 2010, sales of sand for flat glass production increased by 21% compared with those in 2009. Consumption of sand for flat glass increased in all regions of the country in 2010.

Whole grain silica is regularly used in filler-type and building applications. In 2010, consumption of whole-grain fillers for building products was 1.8 Mt, up 6% compared with that in 2009.

In table 6, industrial sand and gravel that would find its way into specialty silicas is most likely reported by the producers in the categories "Sand, abrasives, chemicals, ground and unground," "Gravel, silicon, ferrosilicon," and possibly "Glassmaking, specialty." In 2010, silica sales for chemical production were 808,000 t, an increase of about 21% compared with those in 2009. Reported sales of silica gravel for silicon and ferrosilicon production, filtration, and other uses, increased by 3% in 2010 compared with those in 2009. The main uses for silicon metal are in the manufacture of silanes and semiconductor-grade silicon and in the production of aluminum alloys.

Transportation.—Of all industrial sand and gravel produced, 52% was transported by truck from the plant to the site of first sale or use, unchanged from that of 2009; 20% was transported by rail, down from that of 2009; and 28% by unspecified modes of transport.

Prices.—The average value, free on board plant, of U.S. industrial sand and gravel increased to $34.58 per metric ton in 2010, compared with the average value of 2009 (table 6). The average unit values for industrial sand and industrial gravel were $34.76 per ton and $25.58 per ton, respectively. The average price for sand ranged from $8.40 per ton for metallurgical flux for metal smelting to $143.71 per ton for ground sand for foundry molding and core. For gravel, prices ranged from $21.42 per ton for silicon and ferrosilicon to $44.61 per ton for filtration. Producer prices reported to the USGS for silica commonly ranged from several dollars per ton to hundreds of dollars per ton. Prices for certain highly processed quartz products for specialized end uses, not covered in this chapter, can reach the $50,000-per-ton level. Nationally, ground sand for foundry molding and core had the highest value ($143.71 per ton), followed by silica for swimming pool filters ($99.94 per ton), silica for sawing and sanding ($81.00 per ton), ground sand used as fillers for paint, putty, and rubber ($78.61 per ton), sand for municipal water filtration ($69.77 per ton), ground sand for ceramics ($69.44 per ton), and sand for other ground silica ($63.63 per ton).

By geographic region, the average value of industrial sand and gravel was highest in the Midwest ($35.06 per ton), followed by the South ($35.03 per ton), the Northeast ($34.02 per ton), and the West ($29.38 per ton) (table 6). Prices can vary greatly for similar grades of silica at different locations in the United States, along with tighter supplies and higher production costs in certain regions of the country. For example, the average value of container glass sand varied from $27.63 per ton in the West to $15.79 per ton in the Midwest.

Foreign Trade.—Exports of industrial sand and gravel in 2010 increased by about 84% compared with the amount exported in 2009, and the associated value increased by 85% (table 8). The increase in exports can be attributed mainly to increased demand from markets in Asia, Europe, and Oceania. Canada was the leading recipient of U.S. exports. The distribution of exports was as follows: 44% to Canada, 32% to Japan, 12% to Mexico, and the remainder to Africa and the Middle East, Europe, Oceania, and South America. The average unit value of exports increased slightly to $81.81 per ton in 2010 from $81.31 per ton in 2009. In 2010, export unit values varied widely by region; exports of silica to Oceania averaged $488 per ton, and exports to the rest of the world averaged $81 per ton.

Imports for consumption of industrial sand and gravel increased to 131,000 t, which was an increase of 38% compared with those of 2009 (table 9). Canada supplied about 79% of the silica imports, which averaged $40 per ton; this price included insurance and freight costs to the U.S. port of entry. The total value of imports was $19.7 million, with an average unit value of $150 per ton. Higher priced imports came from Australia, China, Germany, and Japan.

World Review.—Based on information provided mainly by foreign governments, world production of industrial sand and gravel was estimated to be 121 Mt (table 10). The United States was the leading producer followed, in descending order, by Italy, Germany, Australia, France, Spain, Turkey, and the United Kingdom. Most countries had some production and consumption of industrial sand and gravel, which are essential to the glass and foundry industries. Because of the great variation in reporting standards, however, obtaining reliable information was difficult. In addition to the countries listed, many other countries were thought to have had some type of silica production and consumption.

Outlook.—U.S. consumption of industrial sand and gravel in 2011 was expected to be 29 to 31 Mt. All forecasts are based on previous performances within various end uses, contingency factors considered relevant to the future of the commodity, and forecasts made by analysts and producers in the various markets.

Sales of glass sand can be expected to vary by market. Total demand for all glass sand end uses was expected to remain relatively static through 2011. However, growth has been noted in some segments, such as sand for abrasives, chemicals, fiberglass, flat glass, hydraulic fracturing, well packing and cementing, and whole grain silica. Industrial sand and gravel sales may also be constrained by diminished demand owing to the ongoing economic sluggishness and by the rising energy costs for production and transportation of products.

The demand for foundry sand is dependent mainly on automobile and light truck production. Production and sales of automobiles and light trucks increased in 2010 and the trend continued into 2011. Another important factor for the future consumption of virgin foundry sand is the recycling of used foundry sand. The level of recycling is thought to be increasing. Other materials or minerals compete with silica as foundry sand, but these other "sands" usually suffer from a severe price disadvantage. Based on these factors, production of silica foundry sand in 2011 was expected to be 3.5 Mt.

Frac sand sales increased in 2010 compared with those in 2009. On average, crude oil prices increased in 2010 with further increases in 2011. Based on this trend, coupled with natural gas exploration and production, primarily in the Eastern and Midwestern United States, demand for frac sand was expected to increase during 2011 to 16 Mt.

The United States is the leading producer and a major consumer of silica sand and is self-sufficient in this mined mineral commodity. Most silica sand is produced at deposits in the Midwest and near major markets in the Eastern United States. A significant amount of silica sand also is produced in the West and Southwest, mostly in California and Texas, respectively. Domestic production is expected to continue to meet 97% to 98% of demand well beyond 2011. Barring further declines in the overall U.S. economy, imports of silica sand from Canada and Mexico, and higher valued material from China are expected to slowly increase.

Because the unit price of silica sand is relatively low, except for a few end uses that require a high degree of processing, the location of a silica sand deposit in relation to market location is an important factor that may work for or against a sand producer. Consequently, a significant number of relatively small operations supply local markets with a limited number of products.

Several factors could affect supply and demand relationships for silica sand. Further increases in the development of substitute materials for glass and cast metals could reduce demand for foundry and glass sand. These substitutes, which are mainly ceramics and polymers, would likely increase the demand for ground silica, which is used as a filler in plastics; glass fibers, which are used in reinforced plastics; and silica (chemical, ground, or whole-grain), which is used as raw materials for ceramics. Increased efforts to reduce waste and to increase recycling also would be likely to lower the demand for mined glass sand. Recycling of glass cullet has been increasing in most industrialized nations, and recycling has accounted for anywhere from 25% to 70% of the raw material needed for the glass container industry in many countries. It has been estimated that for every 10% of recycled glass cullet used in the melting process for glass container manufacture, energy use will fall by approximately 2.5%. During the past 20 years, glass container weight has been reduced by 25% to 40% in many nations, including the United States, decreasing the amount of industrial sand required for each container (Industrial Minerals, 2004). Although other developments likely would cause the demand for silica sand to decrease, the total value of production likely would increase because of the increased unit value of the more specialized sands.

Health concerns about the use of silica as an abrasive and stricter legislative and regulatory measures concerning crystalline silica exposure could reduce the demand in many silica markets. The use of silica sand in the abrasive blast industry was being evaluated as a health hazard, and marketers of competing materials, which include garnet, olivine, and slags, encouraged the use of their "safer" abrasive media. In hydraulic fracturing, other materials (such as bauxite-based proppants, ceramic proppants, and resin-coated sand) compete with silica sand, although they are more expensive and not used as extensively as silica sand. Bauxite-based and ceramic proppants exhibit improved performance in deeper, higher pressure formations than silica sand (Industrial Minerals, 2009).

Quartz Crystal

Electronic-grade quartz crystal, also known as cultured quartz crystal, is single-crystal silica with properties that make it uniquely suited for accurate filters, frequency controls, and timers used in electronic circuits. These devices are used for a variety of electronic applications in aerospace hardware, commercial and military navigational instruments, communications equipment, computers, and consumer goods (for example, clocks, games, television receivers, and toys). Such uses generate practically all the demand for electronic-grade quartz crystal. A smaller amount of optical-grade quartz crystal is used for lenses and windows in specialized devices, which include some lasers.

Natural quartz crystal was used in most electronic and optical applications until 1971, when it was surpassed by cultured quartz crystal. Cultured quartz is not a mined mineral commodity. Rather, it is synthetically produced from natural feedstock quartz, termed lascas, which is mined. Mining of lascas in the United States ceased in 1997 owing to competition from less expensive imported lascas, predominantly from mines in Brazil and Madagascar.

It has been estimated that in any given year, approximately 10 billion quartz crystals and oscillators are manufactured and installed worldwide in all types of electronic devices, from automobiles to cellular telephones.

The use of natural quartz crystal for carvings and other gemstone applications has continued; more information can be found in the "Gemstones" chapter of the USGS Minerals Yearbook, volume I, Metals and Minerals.

Legislation and Government Programs.—The strategic value of quartz crystal was demonstrated during World War II when it gained widespread use as an essential component of military communication systems. After the war, natural electronic-grade quartz crystal was officially designated as a strategic and critical material for stockpiling by the Federal Government. Cultured quartz crystal, which eventually supplanted natural crystal in nearly all applications, was not commercially available when acquisition of natural quartz crystal for a national stockpile began.

As of December 31, 2010, the National Defense Stockpile (NDS) contained 7,134 kilograms (kg) of natural quartz crystal. The stockpile has 11 weight classes for natural quartz crystal that range from 0.2 kg to more than 10 kg. The stockpiled crystals, however, are primarily in the larger weight classes. The larger pieces are suitable as seed crystals, which are very thin crystals cut to exact dimensions, to produce cultured quartz crystal. In addition, many of the stockpiled crystals could be of interest to the specimen and gemstone industry. Little, if any, of the stockpiled material is likely to be used in the same applications as cultured quartz crystal.

No natural quartz crystal was sold from the NDS in 2010, and the Federal Government did not intend to dispose of or sell any of the remaining material. Previously, only individual crystals in the NDS inventory that weighed 10 kg or more and could be used as seed material were sold. Brazil traditionally has been the source of such large natural crystals, but changes in mining operations have reduced output.

Quartz crystal is also affected by the regulation of crystalline silica as discussed in the "Legislation and Government Programs" portion of the "Industrial Sand and Gravel" section of this chapter.

Production.—The USGS collects production data for quartz crystal through a survey of the domestic industry. In 2010, no domestic companies reported the production of cultured quartz crystal. During the past several years, cultured quartz crystal was produced predominantly overseas, primarily in Asia.

Consumption.—In 2010, the USGS collected domestic consumption data for quartz crystal through a survey of 23 U.S. operations that fabricate quartz crystal devices in 9 States. Of the 23 operations, 8 responded to the survey. Consumption for nonrespondents was estimated based on reports from previous years.

Prices.—Lumbered quartz, which is as-grown cultured quartz that has been processed by sawing and grinding, was estimated to be $210 per kilogram in 2010. Prices for lumbered quartz ranged in price from $20 per kilogram to more than $900 per kilogram in 2010, depending on the application.

Foreign Trade.—The U.S. Census Bureau, which is the major Government source of U.S. trade data, does not provide specific import or export statistics on lascas. The U.S. Census Bureau collects export and import statistics on electronic and optical-grade quartz crystal; however, the quartz crystal export and import quantities and values reported in previous years included zirconia, which was inadvertently reported as quartz crystal, not including mounted piezoelectric crystals.

World Review.—Cultured quartz crystal production was concentrated in China, Japan, and Russia; several companies produced crystal in each country. Other producing countries were Belgium, Brazil, Bulgaria, France, Germany, South Africa, and the United Kingdom. Details concerning quartz operations in China, the Eastern European countries, and most nations of the Commonwealth of Independent States were unavailable. Operations in Russia, however, have significant capacity to produce synthetic quartz.

Outlook.—Growth of the consumer electronics market (for example, automobiles, cellular telephones, electronic games, and personal computers), particularly in the United States, will likely continue to provide consumer outlets for domestic production of quartz crystal devices. The increasing global electronics market may require additional production capacity worldwide. Quartz technology could face competition in the near future with the advent of more cost effective microelectromechanical systems (MEMS). MEMS technology was first developed in 1965 and consisted of silicon on insulated wafers. MEMS technology is physically compatible with existing quartz oscillator products and has better long-term stability performance characteristics for use in automotive, consumer, and computational products, and wireless applications (Partridge, 2006).

Special Silica Stone Products

Silica stone (another type of crystalline silica) products are materials for abrasive tools, such as deburring media, grinding pebbles, grindstones, hones, oilstones, stone files, tube-mill liners, and whetstones. These products are manufactured from novaculite, quartzite, and other microcrystalline quartz rock. This chapter, however, excludes products that are fabricated from such materials by artificial bonding of the abrasive grains (information on other manufactured and natural abrasives may be found in other USGS Minerals Yearbook, volume I, Metals and Minerals chapters).

Special silica stone is also affected by the regulation of crystalline silica as discussed in the "Legislation and Government Programs" part of the "Industrial Sand and Gravel" section of this chapter.

Production.—None of the three domestic firms known to produce special silica stone responded to a USGS production survey in 2010. To protect the proprietary data of all producers, production and value data for special silica stone in 2010 were withheld (table 1). In recent years, Arkansas accounted for most of the value and quantity of production that was reported. Plants in Arkansas manufactured files, deburring-tumbling media, oilstones, and whetstones.

The industry produced and marketed four main grades of Arkansas whetstone in recent years. The grades range from the high-quality black hard Arkansas stone down to Washita stone. In general, the black hard Arkansas stone has a porosity of 0.07% and a waxy luster, and Washita stone has a porosity of 16% and resembles unglazed porcelain.

Consumption.—The domestic consumption of special silica stone products comprises a combination of craft, household, industrial, and leisure uses. The leading household use is for sharpening knives and other cutlery, lawn and garden tools, scissors, and shears. Major industrial uses include deburring metal and plastic castings, polishing metal surfaces, and sharpening and honing cutting surfaces. The major recreational use is in sharpening arrowheads, fishhooks, spear points, and sports knives. The leading craft application is sharpening tools for engraving, jewelry making, and woodcarving. Silica stone files also are used in the manufacture, modification, and repair of firearms.

Prices.—In 2010, the average value of crude material suitable for cutting into finished products was estimated to be $3,700 per ton.

Foreign Trade.—In 2010, silica stone product exports had a value of $11.3 million, up by 48% from that in 2009. These exports were categorized as "hand sharpening or polishing stones" by the U.S. Census Bureau. This category accounted for most of or all the silica stone products exported in 2010.

In 2010, the value of imported silica stone products was $8.9 million, up by 8% from that in 2009. These imports were hand sharpening or polishing stones, which accounted for most of or all the imported silica stone products in 2010. A portion of the finished products that were imported may have been made from crude novaculite produced in the United States and exported for processing.

Outlook.—Consumption patterns for special silica stone were not expected to change significantly during the next several years. Most of the existing markets are well defined, and the probability of new uses being created is low.

Tripoli

Tripoli, broadly defined, includes extremely fine grained crystalline silica in various stages of aggregation. Grain sizes usually range from 1 to 10 micrometers (µm), but particles as small as 0.1 to 0.2 µm are common. Commercial tripoli contains 98% to 99% silica and minor amounts of alumina (as clay) and iron oxide. Tripoli may be white or some shade of brown, red, or yellow depending on the percentage of iron oxide.

Tripoli also is affected by the regulation of crystalline silica as discussed in the "Legislation and Government Programs" part of the "Industrial Sand and Gravel" section of this chapter.

Production.—In 2010, three U.S. firms were known to produce and process tripoli. American Tripoli, Inc. closed their operation in Ottawa County, OK, in 2010, but operated a mine and produced finished material in Newton County, MO. Malvern Minerals Co. in Garland County, AR, produced crude and finished material from novaculite. Unimin Specialty Minerals Inc. in Alexander County, IL, produced crude and finished material. Of the three U.S. firms, none responded to the USGS survey. Production for nonrespondents was estimated based on reports from previous years and supplemented with worker-hour reports from MSHA.

Consumption.—It was estimated that sales of processed tripoli increased by 38% in quantity to 110,000 t with a value of $20 million (table 1).

Tripoli has unique applications as an abrasive because of its hardness and its grain structure, which lacks distinct edges and corners. It is a mild abrasive, which makes it suitable for use in toothpaste and tooth-polishing compounds, industrial soaps, and metal- and jewelry-polishing compounds. The automobile industry uses it in buffing and polishing compounds for lacquer finishing.

The end-use pattern for tripoli has changed significantly in the past 40 years. In 1970, nearly 70% of the processed tripoli was used as an abrasive. In 2010, 6% of tripoli output was used as an abrasive. Tripoli was mostly used as a filler and extender in enamel, caulking compounds, linings, paint, plastic, rubber, and other products. In 2010, the primary use of tripoli (91%) was as a filler and extender. The remaining 3% was in brake friction products and refractories.

Price.—The average unit value of all tripoli sold or used in the United States was estimated to be $181 per ton in 2010. The average unit value of abrasive-grade tripoli sold or used in the United States during 2010 was estimated to be $191 per ton, and the average unit value of filler-grade tripoli sold or used domestically was estimated to be $186 per ton.

Outlook.—Consumption patterns for tripoli were not expected to change significantly during the next several years. Most of the existing markets are well defined, and the probability of new uses being created is low.

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TABLE 1
SALIENT U.S. SILICA STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

	2006	2007	2008	2009	2010
Industrial sand and gravel:[2]					
Sold or used:					
Quantity:					
Sand	28,200	29,000	29,300	24,000	29,300
Gravel	725	1,010	1,110	565	582
Total	28,900	30,100	30,400	24,600	29,900
Value:					
Sand	745,000	810,000	909,000	762,000	1,020,000
Gravel	13,400	21,300	28,000	21,000	14,900
Total	759,000	832,000	937,000 r	783,000	1,030,000
Exports:					
Quantity	3,830	3,020	3,100	2,150	3,950
Value	183,000	242,000	260,000	175,000	323,000
Imports for consumption:					
Quantity	855	511	355	95	131
Value	21,000	24,000	23,500	8,080	19,700
Processed tripoli:[3]					
Quantity metric tons	76,000	96,400	132,000	79,700	110,000
Value	17,500	17,400	17,100	16,400	20,000
Special silica stone:					
Crude production:					
Quantity metric tons	227	231	W	W	W
Value	992	1,020	W	W	W
Sold or used:					
Quantity metric tons	328	508	W	W	W
Value	1,460	823	W	W	W

rRevised. W Withheld to avoid disclosing company proprietary data.
[1] Data are rounded to no more than three significant digits; may not add to totals shown.
[2] Excludes Puerto Rico.
[3] Includes amorphous silica and Pennsylvania rottenstone.

TABLE 2

INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES, BY GEOGRAPHIC DIVISION[1]

	2009				2010			
Geographic region	Quantity (thousand metric tons)	Percentage of total	Value (thousands)	Percentage of total	Quantity (thousand metric tons)	Percentage of total	Value (thousands)	Percentage of total
Northeast:								
New England	130	(2)	$4,510	(2)	127	(2)	$6,380	1
Middle Atlantic	1,670	7	48,200	6	1,440	5	47,000	5
Midwest:								
East North Central	8,470	34	266,000	34	9,910	33	346,000	33
West North Central	2,630	11	113,000	14	4,600	15	163,000	16
South:								
South Atlantic	3,480	14	89,900	11	3,480	12	93,400	9
East South Central	1,210	5	39,200	5	1,290	4	40,900	4
West South Central	4,780	19	164,000	21	6,880	23	274,000	26
West:								
Mountain	531	2	12,600	2	500	2	14,000	1
Pacific	1,670	7	45,600	6	1,680	6	49,900	5
Total	24,600	100	783,000	100	29,900	100	1,030,000	100

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

TABLE 3
INDUSTRIAL SAND AND GRAVEL SOLD OR USED IN THE UNITED STATES, BY STATE[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
State	Quantity	Value	Quantity	Value
Alabama	370	11,200	386	10,400
Arizona	W	W	W	W
Arkansas	W	W	W	W
California	1,300	35,800	1,320	39,400
Colorado	W	W	W	W
Florida	431	8,270	173	3,980
Georgia	775	19,300	670	17,800
Idaho	W	W	W	W
Illinois	3,440	104,000	4,370	148,000
Indiana	W	W	W	W
Iowa	W	W	W	W
Kansas	W	W	W	W
Louisiana	682	25,900	629	25,600
Michigan	1,330	27,700	1,260	27,300
Minnesota	W	W	1,940	100,000
Mississippi	W	W	--	--
Missouri	763	28,900	608	20,000
Nebraska	W	W	W	W
Nevada	W	W	W	W
New Jersey	906	30,200	918	33,600
New York	W	W	W	W
North Carolina	1,300	28,000	1,400	30,900
North Dakota	W	W	W	W
Ohio	849	26,300	821	27,800
Oklahoma	1,410	40,300	1,900	57,200
Pennsylvania	618	15,600	524	13,400
Rhode Island	W	W	W	W
South Carolina	441	14,000	530	14,700
Tennessee	783	27,100	907	30,500
Texas	2,130	84,400	3,610	162,000
Virginia	W	W	W	W
Washington	W	W	W	W
West Virginia	241	14,700	277	17,300
Wisconsin	2,730	105,000	3,390	142,000
Other	4,070	137,000	10,600	317,000
Total	24,600	783,000	29,900	1,030,000

W Withheld to avoid disclosing company proprietary data; included in "Other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4
INDUSTRIAL SAND AND GRAVEL PRODUCTION IN THE UNITED STATES IN 2010, BY SIZE OF OPERATION[1]

Size range	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total
Less than 25,000	21	18	207	(2)
25,000 to 49,999	17	15	586	2
50,000 to 99,999	14	12	938	3
100,000 to 199,999	15	13	1,850	6
200,000 to 299,999	9	8	1,930	6
300,000 to 399,999	8	7	2,490	8
400,000 to 499,999	5	4	1,980	7
500,000 to 599,999	8	7	3,930	13
600,000 to 699,999	4	3	2,340	8
700,000 and more	15	13	13,700	46
Total	116	100	29,900	100

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

TABLE 5
NUMBER OF INDUSTRIAL SAND AND GRAVEL OPERATIONS AND PROCESSING PLANTS IN THE UNITED STATES IN 2010, BY GEOGRAPHIC DIVISION

Geographic region	Mining operations on land: Stationary	Mining operations on land: Portable	Mining operations on land: Stationary and portable	Dredging operations	Total active operations
Northeast:					
New England	1	--	--	--	1
Middle Atlantic	4	--	--	3	7
Midwest:					
East North Central	23	--	--	3	26
West North Central	9	--	--	3	12
South:					
South Atlantic	16	1	--	5	22
East South Central	7	--	--	2	9
West South Central	17	--	--	7	24
West:					
Mountain	4	--	--	--	4
Pacific	11	--	--	--	11
Total	92	1	--	23	116

-- Zero.

TABLE 6

INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 2010, BY MAJOR END USE[1]

Major use	Northeast			Midwest			South		
	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)	Quantity (thousand metric tons)	Value (thousands)	Unit value[2] (dollars per ton)
Sand:									
Glassmaking:									
Containers	W	W	$24.07	1,060	$16,700	$15.79	1,770	$37,500	$21.25
Flat, plate and window	134	$2,940	21.90	851	17,300	20.34	1,070	23,900	22.39
Specialty	103	3,470	33.65	155	5,370	34.62	152	5,990	39.43
Fiberglass, unground	W	W	22.42	132	2,190	16.58	362	8,670	23.95
Fiberglass, ground	--	--	--	30	1,980	66.07	387	18,800	48.55
Foundry:									
Molding and core, unground	72	2,300	31.99	2,460	47,500	19.31	554	11,800	21.32
Molding and core, ground	--	--	--	6	886	147.67	W	W	119.00
Refractory	(3)	29	--	20	719	35.95	23	1,130	48.91
Metallurgical, flux for metal smelting	--	--	--	--	--	--	(3)	W	--
Abrasives:									
Blasting	W	W	22.32	40	1,790	44.75	306	12,600	41.07
Scouring cleaners (ground)	--	--	--	(3)	59	--	(3)	1	--
Sawing and sanding	W	W	117.00	--	--	--	W	W	45.00
Chemicals, ground and unground	3	133	44.33	278	5,700	20.52	510	18,600	36.54
Fillers, ground, rubber, paints, putty, etc.	5	323	64.60	W	W	48.94	W	W	250.23
Whole-grain fillers/building products	252	11,400	45.29	357	14,100	39.63	798	27,500	34.50
Ceramic, ground, pottery, brick, tile, etc.	(3)	6	--	29	2,330	80.31	60	3,900	64.97
Filtration:									
Water, municipal, county, local	46	3,170	68.87	65	4,440	68.25	51	3,940	77.22
Swimming pool, other	11	988	89.82	11	1,160	105.73	41	4,250	103.54
Petroleum industry:									
Hydraulic fracturing	W	W	44.15	8,080	354,000	43.78	3,820	185,000	48.43
Well packing and cementing	5	570	114.00	87	4,070	46.77	76	3,730	49.01
Recreational:									
Golf course, greens and traps	43	1,620	37.72	171	4,140	24.18	246	3,580	14.57
Baseball, volleyball, play sand, beaches	21	3,140	149.67	31	721	23.26	68	1,550	22.85
Traction, engine	14	555	39.64	24	446	18.58	30	855	28.50
Roofing granules and fillers	32	1,210	37.91	82	2,050	24.96	208	4,390	21.09
Other, ground silica	W	W	49.00	199	9,770	60.67	47	9,420	49.64
Other, whole grain	809	20,700	25.65	256	9,650	37.92	604	8,690	14.64
Total or average	1,560	52,600	33.81	14,400	507,000	35.15	11,200	396,000	35.42
Gravel:									
Silicon, ferrosilicon	--	--	--	--	--	--	173	3,710	21.42
Filtration	W	W	69.67	W	W	39.38	48	1,980	41.33
Other uses, specified	W	W	41.75	W	W	14.10	255	6,560	25.73
Total or average	14	794	56.71	82	1,490	18.11	475	12,200	25.78
Grand total or average	1,570	53,400	34.02	14,500	509,000	35.06	11,700	408,000	35.03

See footnotes at end of table.

TABLE 6—Continued
INDUSTRIAL SAND AND GRAVEL SOLD OR USED BY U.S. PRODUCERS IN 2010, BY MAJOR END USE[1]

Major use	West Quantity (thousand metric tons)	West Value (thousands)	West Unit value[2] (dollars per ton)	U.S. total Quantity (thousand metric tons)	U.S. total Value (thousands)	U.S. total Unit value[2] (dollars per ton)
Sand:						
Glassmaking:						
Containers	713	$19,700	$27.63	3,950	$83,900	$21.24
Flat, plate and window	476	13,700	28.83	2,530	57,800	22.88
Specialty	W	W	51.33	416	15,100	36.38
Fiberglass, unground	49	1,270	25.98	602	13,500	22.35
Fiberglass, ground	W	W	52.86	424	21,100	49.86
Foundry:						
Molding and core, unground	34	809	23.79	3,120	62,400	20.00
Molding and core, ground	--	--	--	W	W	143.71
Refractory	(3)	(3)	--	44	1,870	42.57
Metallurgical, flux for metal smelting	W	W	8.30	W	W	8.40
Abrasives:						
Blasting	80	1,360	16.94	469	16,700	35.59
Scouring cleaners (ground)	--	--	--	(3)	60	--
Sawing and sanding	--	--	--	W	W	81.00
Chemicals, ground and unground	18	556	30.89	808	25,000	30.98
Fillers, ground, rubber, paints, putty, etc.	W	W	38.33	239	18,800	78.61
Whole grain fillers/building products	411	15,600	37.84	1,820	68,600	37.76
Ceramic, ground, pottery, brick, tile, etc.	W	W	43.00	91	6,320	69.44
Filtration:						
Water, municipal, county, local	16	807	50.44	177	12,400	69.77
Swimming pool, other	--	--	--	64	6,400	99.94
Petroleum industry:						
Hydraulic fracturing	W	W	35.41	12,100	546,000	45.24
Well packing and cementing	15	1,790	119.00	183	10,100	55.46
Recreational:						
Golf course, greens and traps	87	2,220	25.46	548	11,600	21.09
Baseball, volleyball, play sand, beaches	2	43	21.50	123	5,460	44.40
Traction, engine	5	242	48.40	72	2,100	29.14
Roofing granules and fillers	W	W	32.33	358	8,810	24.61
Other, ground silica	25	1,060	37.54	38	2,420	63.63
Other, whole grain	234	4,470	12.33	1,900	43,600	11.97
Total or average	2,160	63,600	29.38	29,300	1,020,000	34.76
Gravel:						
Silicon, ferrosilicon	--	--	--	173	3,710	21.42
Filtration	--	--	--	70	3,120	44.61
Other uses, specified	12	338	--	338	8,030	23.77
Total or average	12	338	28.17	582	14,900	25.58
Grand total or average	2,180	63,900	29.38	29,900	1,030,000	34.58

W Withheld to avoid disclosing company proprietary data; for sand, included in "Other, whole grain"; for gravel, included in "Total or average."

-- Zero.

[1] Data are rounded to no more than three significant digits except for unit values; may not add to totals shown.

[2] Calculated using unrounded data.

[3] Less than ½ unit.

TABLE 7
INDUSTRIAL SAND AND GRAVEL SOLD OR USED, BY DESTINATION[1]

(Thousand metric tons)

Destination	2009	2010
States:		
Alabama	361	341
Alaska	W	W
Arizona	W	W
Arkansas	748	410
California	W	1,260
Colorado	1,050	W
Connecticut	67	W
Delaware	30	W
District of Columbia	W	W
Florida	657	W
Georgia	788	614
Hawaii	W	W
Idaho	W	W
Illinois	1,280	1,500
Indiana	792	712
Iowa	W	W
Kansas	194	W
Kentucky	W	189
Louisiana	480	W
Maine	W	W
Maryland	W	W
Massachusetts	W	W
Michigan	341	359
Minnesota	W	W
Mississippi	52	W
Missouri	W	W
Montana	9	W
Nebraska	W	W
Nevada	W	W
New Hampshire	W	W
States—Continued:		
New Jersey	W	W
New Mexico	90	68
New York	W	W
North Carolina	W	W
North Dakota	167	230
Ohio	588	425
Oklahoma	516	754
Oregon	65	W
Pennsylvania	W	1,270
Rhode Island	22	W
South Carolina	W	W
South Dakota	W	W
Tennessee	471	639
Texas	3,020	4,350
Utah	W	W
Vermont	W	W
Virginia	172	206
Washington	W	W
West Virginia	74	W
Wisconsin	1,130	W
Wyoming	371	W
Countries:		
Canada	298	322
Mexico	293	174
Other	7	W
Other:		
Puerto Rico	W	W
U.S. possessions and territories	W	--
Destination unknown	3,940	8,890
Total	24,600	29,900

W Withheld to avoid disclosing company proprietary data; included in "Total." --Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 8

U.S. EXPORTS OF INDUSTRIAL SAND AND GRAVEL, BY REGION AND COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
Destination	Quantity	Value[2]	Quantity	Value[2]
Africa and the Middle East:				
Egypt	--	--	(3)	91
Israel	(3)	301	(3)	204
Other	6	938	--	1,380
Total	7	1,240	2	1,680
Asia:				
China	23	36,000	133	82,400
Hong Kong	(3)	267	2	584
Japan	396	15,500	1,270	51,300
Korea, Republic of	9	2,950	18	3,790
Singapore	1	966	4	1,420
Taiwan	4	1,210	1	1,010
Other	4	984	3	1,450
Total	437	57,800	1,430	142,000
Europe:				
Belgium	3	1,640	2	1,390
Germany	34	19,800	105	39,000
Italy	1	700	1	167
Netherlands	52	4,260	115	7,630
Russia	(3)	20	(3)	140
United Kingdom	5	2,430	2	2,340
Other	5	10,700	6	12,300
Total	100	39,500	229	62,900
North America:				
Bahamas, The	(3)	82	1	198
Canada	1,150	43,200	1,750	68,800
Mexico	420	22,600	480	36,300
Trinidad and Tobago	1	410	(3)	93
Other	5	1,260	12	1,970
Total	1,580	67,500	2,250	107,000
Oceania:				
Australia	2	993	3	1,390
New Zealand	(3)	69	(3)	74
Total	2	1,060	3	1,460
South America:				
Argentina	17	3,390	21	3,710
Brazil	3	1,480	1	1,350
Colombia	4	1,650	2	501
Peru	2	445	15	1,980
Venezuela	(3)	264	(3)	133
Other	2	418	1	412
Total	28	7,640	40	8,080
Grand total	2,150	175,000	3,950	323,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship value of material at U.S. port of export. Based on transaction price, includes all charges incurred in placing material alongside ship.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF INDUSTRIAL SAND, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
Country	Quantity	Value[2]	Quantity	Value[2]
Australia	(3)	567	(3)	1,160
Canada	88	4,170	103	4,080
Chile	(3)	62	--	--
China	(3)	160	(3)	281
Germany	(3)	143	(3)	671
Japan	(3)	47	(3)	105
Mexico	5	2,540	26	11,500
Netherlands	(3)	30	--	--
Other	1	372	2	1,860
Total	95	8,080	131	19,700

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Cost, insurance, and freight value of material at U.S. port of entry. Based on purchase price; includes all charges (except U.S. import duties) in bringing material from foreign country to alongside carrier.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10
INDUSTRIAL SAND AND GRAVEL (SILICA): WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Algeria	NA	254	243	118	84[4]
Argentina	446	457	473	364[r]	400
Australia[e]	5,200	5,300	5,300	5,200	5,300
Austria	2,008	1,915[r]	2,175[r]	1,170[r]	939[4]
Belgium[e]	1,800	1,800	1,800	1,800	1,800
Belize[e]	11	12	12	12	1
Bosnia and Herzegovina	711	671	702	501[r]	600
Brazil, silex[e]	2	2	2	2	2
Bulgaria	250	551	734	657[r]	660
Canada, quartz	2,146	1,987	1,979	1,296	1,171[p, 4]
Chile	1,081	1,234	1,401	1,405	1,400
Croatia	140	148	150[e]	278[r]	241[4]
Cuba[e]	9	21	29	16[r]	16
Czech Republic, foundry sand	773	850	702	1,364	1,400
Denmark, sales[e]	60	60	60	60	60
Ecuador[e]	36[4]	36	36	36	--
Egypt[5]	650[e]	1,725	1,612	1,342[r]	1,757[4]
Eritrea	1[r]	NA[r]	NA[r]	NA[r]	NA
Estonia, industrial sand	--	--	--	--	36[4]
Ethiopia[6]	6[e]	6	7	15[r]	30
Finland	3,003	2,958	3,160	2,241	2,250
France[e]	5,000	5,000	5,000	5,000	5,000
French Guyana[e]	1,500	1,500	1,500	1,500	1,500
Gambia	1,390[e]	712	1,065	850[r]	897[4]
Germany	7,703	8,382	8,186	6,453	7,000
Greece	100[e]	100[e]	65	38	38
Guatemala	58	68	65	36	62[4]
Guyana[7]	285	715	684	479	652
Hungary, foundry and glass sand	371[r]	337[r]	320[r]	196[r]	180[4]
Iceland[e]	4	4	4	4	4
India[e]	1,600	1,600	1,700	1,700	1,800
Indonesia[e]	135	135	138	138	140
Iran[e, 8]	1,900[4]	2,000	2,000	1,500	1,500
Iraq	--	(9)	19	18	(9)[4]
Ireland[e]	5	5	5	5	5
Israel	204	220	195[r]	163[r]	198[4]
Italy[e]	14,000[r]	14,000[r]	14,000[r]	19,759[r, 4]	19,800
Jamaica	10	14	15	7	13[4]
Japan	4,593	4,314	3,664	2,856[r]	3,078[4]
Jordan	392	628	23[r]	298[r]	300
Kenya[e]	34	34	34	30[r]	32
Korea, Republic of	1,437	2,227	1,757	455	535[4]
Latvia	2,133[r]	4,285[r]	2,223[r]	1,339[r]	1,359[4]
Lithuania	43	45	38	42[r]	67[4]
Malaysia	512	719	1,467	630[r]	932[4]
Mexico	2,662	2,950[r]	2,779	2,484[r]	2,480
Netherlands[e]	5	5	5	5	5
New Caledonia[e]	--[r]	--[r]	--[r]	--[r]	--
New Zealand	59	86	49	43[r]	45
Nigeria	--	--	--	32	30
Norway[e]	1,500	1,500	1,500	1,500	1,500
Paraguay[e]	25	25	25	25	25
Peru[e]	900	900	900	900	900
Philippines	179	221[r]	270[r]	284[r]	300
Poland	1,525[r]	2,268[r]	2,398[r]	2,731[r]	2,730

See footnotes at end of table.

TABLE 10—Continued
INDUSTRIAL SAND AND GRAVEL (SILICA): WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Portugal[e]	5	5	5	5	5
Romania[e]	522 [4]	520	520	520	520
Saudi Arabia	781 [r, e]	820 [r, e]	799	709 [r]	820 [4]
Serbia[e]	260	260	260	260	260
Slovakia	524 [r]	591 [r]	619 [r]	502 [r]	500
Slovenia	350 [r, e]	350 [r, e]	354 [r]	327 [r]	330
South Africa	3,216 [r]	3,352	3,648 [r]	2,306	2,910 [4]
Spain[e]	5,100	5,000	5,000	5,000	5,000
Sri Lanka	46	70	61	60	68 [4]
Sweden[e]	700	700	700	700	700
Thailand	862	844	496	500 [r]	500
Turkey	2,608 [r]	4,998 [r]	2,423 [r]	4,499 [r]	4,000
United Kingdom	5,174 [r]	4,909 [r]	4,777 [r]	3,755 [r]	3,760
United States, sold or used by producers	28,900	30,100	30,400	24,600	29,900 [4]
Venezuela[e]	500	500	500	500	500
Zimbabwe[10]	1 [e]	--	--	--	--
Total	118,000 [r]	128,000 [r]	123,000 [r]	114,000 [r]	121,000

[e]Estimated. [p]Preliminary. [r]Revised. NA Not available. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 1, 2011.

[3] In addition to the countries listed, Angola, Antigua and Barbuda, The Bahamas, China, and countries of the Commonwealth of Independent States produce industrial sand, but current available information is inadequate to formulate reliable estimates of output levels.

[4] Reported figure.

[5] Fiscal years beginning July 1 of that stated.

[6] Ethiopian calender year ending July 7 of that stated.

[7] Source: Guyana Geology and Mines Commission and the Bank of Guyana.

[8] Fiscal years beginning March 21 of that stated.

[9] Less than ½ unit.

[10] Includes rough and ground quartz as well as silica sand.

SILICON

By Lisa A. Corathers

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant.

In 2010, domestic ferrosilicon production increased by 27% from that of 2009 to 176,000 metric tons (t) of contained silicon (table 1). On a gross-weight basis, ferrosilicon production increased by 26% from 229,000 t produced in 2009 (table 2). Domestic statistics for silicon metal were withheld to avoid disclosing company proprietary data. On the basis of contained silicon, U.S. exports of silicon products increased by 73%, and imports increased by 79%. The increase in exports was primarily associated with increases in the "more than 99.99% silicon" metal and the "more than 55% silicon" ferrosilicon trade categories (table 5). The increase in imports was primarily attributable to increases in the "55% to 80%, other" ferrosilicon and the "99.00% to 99.99%" and "other" silicon metal trade categories (table 6). Apparent consumption for ferrosilicon increased by 51% compared with the revised amount in 2009. Year-average import prices for the 50% and 75% ferrosilicon grades increased by 42% and 41%, respectively, and those for silicon metal increased by 20% compared with those in 2009 (table 1).

Silicon is a light chemical element with metallic and nonmetallic characteristics. Silicon is rarely found free in nature. Silicon combines with oxygen and other elements to form silicates, which comprise more than 25% of the Earth's crust. Silica (SiO_2) as quartz or quartzite is used to produce silicon ferroalloys for the iron and steel industries and silicon metal for the aluminum and chemical industries. Silicon metal that is refined into semiconductor-grade metal for use in making computer chips is crucial to modern technology, but the quantity is less than 5% of total silicon metal demand (Roskill's Letter from Japan, 2000). Silicon metal also may either be used directly in an upgraded metallurgical form or refined into wafers to power solar batteries. The U.S. Geological Survey (USGS) does not survey the ultrahigh-purity silicon industry for production and related data; therefore, the only information in this report about these high-purity grades is from foreign trade statistics and from published sources.

Production

Silicon Ferroalloys.—Domestic production data for silicon ferroalloys are derived from monthly and annual voluntary surveys and estimates for nonrespondents by the USGS. The data in table 2 were obtained from all operations listed in table 3 that are canvassed by means of the USGS "Silicon Alloys" survey. In terms of gross weight and compared with that of 2009, domestic ferrosilicon gross production and net shipments increased by 26% and 29%, respectively. Producer stocks of ferrosilicon at yearend 2010 increased by 39% compared with those at yearend 2009. Data for ferrosilicon reflected adjustments in inventory and in-plant consumption of ferrosilicon to produce magnesium ferrosilicon and other miscellaneous alloys.

In April, Globe Specialty Metals, Inc. (GSM; owner of U.S.-based silicon producer Globe Metallurgical, Inc.) acquired Coraopolis, PA-headquartered Core Metals Group, LLC for $52 million in cash from Ospraie Funds. Core Metals Group had the capacity to produce 42,000 metric tons per year (t/yr) of silicon alloys at its Bridgeport, AL, plant (Globe Specialty Metals, Inc., 2010a).

Silicon Metal.—Production-related statistics for silicon metal were withheld to avoid disclosing company proprietary data. In February, GSM reopened its 27,000-t/yr silicon metal plant in Selma, AL (Globe Specialty Metals, Inc., 2010b).

Semiconductor- and Solar-Battery-Grade Silicon.—U.S. production capacity for polycrystalline silicon used in semiconductor and solar cells was reported to have increased by 26% to 60,500 t in 2010 from that in 2009. The United States led the world in polycrystalline production capacity with 37% of the total, followed by Germany and the Republic of Korea each with 16%. Total annual domestic polycrystalline production capacity by company was as follows: Hemlock Semiconductor Corp., 36,000 t; REC Group (includes REC Advanced Silicon Materials LLC and REC Solar Grade Silicon LLC), 15,000 t; MEMC Electronic Materials, 8,000 t; and Mitsubishi Materials Group, 1,500 t (Roskill's Letters from Japan, 2010b, p. 4).

Upgraded-Metallurgical-Grade Silicon Metal.—Upgraded-metallurgical-grade silicon metal (UMG-Si) is used in silicon-based photovoltaic (solar) cells. UMG-Si does not require as much additional refinement as does polycrystalline silicon, which has been traditionally used in solar panel wafers. GSM did not produce UMG-Si commercially in 2010; rather, the company focused on research and development projects to improve UMG-Si production. GSM's UMG-Si production capacity was 360 t/yr at its Solsil plant in Beverly, OH (Globe Specialty Metals, Inc., 2010c, p. 7, 13).

Consumption

Silicon Ferroalloys and Metal.—Most ferrosilicon (including miscellaneous silicon alloys) was used to produce steel (69%) (table 4). Silicon metal was used mainly to produce chemicals—silanes, silicones, and others—and silica fume (77%). Metallurgical-grade silicon carbide can substitute for ferrosilicon, especially in iron foundries. Data on North American production and U.S. imports of silicon carbide are reported in the Manufactured Abrasives chapter of the 2010 USGS Minerals Yearbook, volume I, Metals and Minerals.

In 2010, apparent consumption of ferrosilicon and miscellaneous silicon alloys increased by 51% to 312,000 t compared with the revised amount of 207,000 t in 2009 (table 1). Increases in domestic production and net imports for consumption contributed to the rise in ferrosilicon apparent consumption. Silicon metal apparent consumption was withheld to avoid disclosing company proprietary data.

Reported consumption of ferrosilicon, which includes miscellaneous silicon alloys, was 44% of apparent consumption (content basis). This percentage was derived based on the typical silicon content of these materials noted in table 4.

Consumption of ferrosilicon and silicon metal was estimated by CRU International Ltd. to have each increased throughout the western world in 2010. In terms of contained silicon, ferrosilicon consumption increased to 1.99 Mt in 2010 from 1.41 Mt (revised) in 2009, and silicon metal consumption increased to 1.49 Mt from 1.03 Mt. Areas with the largest year-to-year increase in consumption of ferrosilicon, in terms of volume, were Europe, Japan, and the United States. Areas with the largest year-to-year increase in silicon metal consumption, in terms of volume and as categorized by CRU International, were the European Union (EU) and other western world countries (excluding the EU and all Asian countries), and the United States. In decreasing order of consumption, Europe, other Asian countries (excluding China, Japan, and North Korea), and Japan accounted for 72% of the ferrosilicon consumption in 2010. Also in decreasing order of consumption, the EU, the United States, and other Asian countries (excluding China, Japan, and North Korea) accounted for 72% of the silicon metal consumed in 2010 (CRU Bulk Ferroalloys Monitor, 2011a, b).

Prices

Ferrosilicon and silicon metal prices (excluding those of ultrahigh-purity silicon) tend to vary in response to changes in supply to, and consumption requirements by, the aluminum, chemical, ferrous foundry, and steel industries. There were significant increases in silicon material prices in 2010 from those in 2009 because of increased consumption in the United States as market conditions improved following the economic downturn that began during the third quarter 2008 and lasted through 2009. The year-average spot prices given by Platts Metals Week were 97.2 cents per pound for 75% ferrosilicon and 140.1 cents per pound for silicon metal; these prices were 41% and 20% higher, respectively, than those of 2009. The year-average North American transaction price for 50% ferrosilicon as calculated from Ryan's Notes listings was 109.3 cents per pound, a 42% increase from that of 2009. Average monthly ferrosilicon and silicon metal spot prices were at their lowest in January 2010 before generally trending upward until hitting a high in November—159 cents per pound for silicon metal, 122.3 cents per pound for 50% ferrosilicon, and 112 cents per pound for 75% ferrosilicon. The range for spot market prices, in cents per pound, ended the year as follows: silicon metal, 155 to 160; 50% ferrosilicon, 115 to 120; and 75% ferrosilicon, 106 to 110.

Foreign Trade

Trade volumes discussed are based on gross weight. U.S. ferrosilicon exports increased by 79% to 25,400 t, and their value increased by 76% to $29.6 million from those of 2009. In decreasing order of quantity, Canada and Mexico accounted for 77% of the total 2010 ferrosilicon exports (table 5). Exports of silicon metal increased by 74% to 65,900 t, and their value increased by 31% to $2.7 billion from that of 2009. In decreasing order of quantity, China, Japan, and Germany accounted for 69% of silicon metal exports. Shipments of high-purity silicon containing more than 99.99% silicon accounted for 76% of total silicon metal exported and 76% of the total value of combined ferrosilicon and silicon metal exports.

U.S. ferrosilicon imports increased by 123% to 229,000 t, and the value of those imports increased by 171% to $342 million compared with that in 2009. These imports increased primarily because of an increase in the "55% to 80% silicon, other" ferrosilicon trade category. Imports of standard 75% ferrosilicon (ferrosilicon category of "55% to 80% silicon, other") accounted for 83% of total ferrosilicon imports by gross weight and 85% of total ferrosilicon value (table 6). Russia (47%) was the leading source of ferrosilicon imports, followed by China (25%) and Canada (13%).

Silicon metal imports (175,000 t) increased by 51% from those in 2009, and increased by 57% in value to $748 million from $477 million in 2009. The increase in silicon metal imports was attributable to increases in the "99.00% to 99.99% silicon" (38,800 t) and "silicon, other" (18,400 t) trade categories. Brazil was the leading source of "99.00% to 99.99% silicon" silicon metal imports at 46%, followed by South Africa at 24% and Australia at 8%. Canada was the leading source of "silicon, other" silicon metal imports at 42%, followed by Brazil at 35% and France at 9%. Silicon metal in the "99.00% to 99.99% silicon" trade category accounted for 81% of the quantity, and 50% of the value, respectively, of all silicon metal imported in 2010. The quantity of silicon metal imports in this trade category increased by 38% compared with that of 2009.

The estimated U.S. net import reliance for ferrosilicon in 2010 as a percentage of apparent consumption decreased to 53% from 54% (revised) in 2009. Silicon metal import reliance was withheld to avoid disclosing company proprietary data.

Antidumping Duty Administrative Reviews.—Final antidumping duty rates assessed in 2010 on imports of silicon materials to the United States are listed in table 7. Results of appeals of import antidumping duty reviews made in 2010 are listed in table 8.

Foreign-Trade Zone Designations.—On December 20, the Foreign-Trade Zones Board of the U.S. Department of Commerce granted foreign-trade zone (FTZ) subzone status with restrictions to Dow Corning Corp.'s silicone manufacturing plants in Carrollton, Elizabethtown, and Shepherdsville, KY, and REC Silicon Inc.'s polysilicon (polycrystalline silicon) and silane gas manufacturing facility in Moses Lake, WA. The FTZ status would allow for antidumping duty deferral, inverted tariffs, and scrap and export savings on imported silicon metal. However, the companies would not be allowed to import silicon metal duty free if those imports were covered by an antidumping duty or countervailing duty order, such as silicon metal imports from China and Russia (Jennemann, 2010; U.S. Department of Commerce, Foreign-Trade Zones Board, 2010a, b).

U.S.-World Trade Organization (WTO) Chinese Raw Material Export Dispute Settlement Proceedings.—On March 29, panel representatives were appointed to the WTO Dispute Settlement Body (DSB) that was formed in response to requests from the EU, Mexico, and the United States regarding curbs placed by China in 2009 on exports of various materials, including a 15% tax on silicon metal exports. The DSB panel was expected to finalize proceedings in April 2011 (Office of the United States Trade Representative, 2009; American Metal Market, 2010a; World Trade Organization Dispute Settlement Body, 2010).

World Industry Structure

Data on annual world production of ferrosilicon and silicon metal by country from 2006 through 2010 are provided in the Ferroalloys chapter of the 2010 USGS Minerals Yearbook, volume I, Metals and Minerals. World production of ferrosilicon, on a gross-weight basis, was estimated to have been 7.89 Mt in 2010 compared with 7.32 Mt (revised) in 2009. The major ferrosilicon producers in 2010 were, in decreasing order, China, Russia, the United States, Norway, and Ukraine; they accounted for 87% of total world production listed in table 1.

World production of silicon metal, excluding that from the United States, was estimated to have been 2.18 Mt in 2010 compared with 1.79 Mt (revised) in 2009 (table 1). China was by far the leading producer of silicon metal in the world in 2010 with an estimated 1.5 Mt; this was 69% of the world total. Other major producers of silicon metal in 2010 were, excluding the United States and in decreasing order, Norway, Brazil, and France; they accounted for 19% of world production reported in table 1. New ferrosilicon and silicon metal projects scheduled for completion around the world from 2010 through 2014 are listed in table 9.

World Review

European Union.—In May, the Council of the European Union assessed new, lower antidumping duties on silicon metal imports from China and the Republic of Korea effective during the next 5 years. An antidumping duty rate of 19% would apply to all silicon metal imports except those from Datong Jinneng Industrial Silicon Co. Ltd., which would be 16.3%. A 49% antidumping duty rate had been in place on silicon metal imports from China and the Republic of Korea since 1990 and 2007, respectively (Official Journal of the European Union, 2010, p. 21).

Bhutan.—Starting in 2008, Bhutan became a new ferrosilicon-producing country. By 2010, there were six ferrosilicon producers in the country—Bhutan Ferro Alloys Ltd. (BFAL); Bhutan Ferro Industries Ltd.; Druk Ferro Alloys Ltd.; Druk Wang Alloys Ltd.; SD Eastern Bhutan Ferro Silicon Pvt. Ltd.; and Ugen Ferroalloys Pvt. Ltd. The country's total ferrosilicon production capacity was estimated to be 100,000 t/yr; BFAL had the largest capacity with 34,000 t/yr. According to the United Nations trade statistics, Bhutan exported most of its ferrosilicon to India (United Nations Statistics Division, unpublished data, August 2011; Wangdi, 2011).

Canada.—In October, Timminco Ltd. and Dow Corning formed a joint venture, dubbed Quebec Silicon, to produce silicon metal at Timminco's wholly owned Becancour Silicon Inc. plant in Becancour, Quebec. Timminco retained 51% ownership in, and operational control of, the plant. Production, initially set at 47,000 t/yr, would be split proportionally between the two companies. Timminco continued to hold 100% equity in UMG-Si production at Becancour under the new name of Timminco Solar. Timminco Solar facilities remained closed in 2010 pending recovery in the solar market, but Quebec Silicon operated at full production capacity to meet the needs of the aluminum and chemical industries (Timminco Ltd., 2010; 2011, p. 2, 10, 14).

China.—China's exports of silicon materials in 2010 were significantly higher than those in 2009 because of improved global economic conditions, despite continued high export tariffs and reduced energy consumption and carbon dioxide (CO_2) emission targets imposed by the Central Government of China in September 2010. China's exports of ferrosilicon increased by 77% to about 735,000 t from the amount exported in 2009. The leading countries of destination for Chinese ferrosilicon were Japan (45%), the Republic of Korea (21%), the United States (6%), and Taiwan (4%). China's exports of silicon metal were also significantly higher in 2010 compared with those in 2009; they were up 50% to 633,464 t from 421,610 t. The leading countries of destination for Chinese silicon metal were Japan (29%), the Republic of Korea (13%), the United Kingdom (7%), and Thailand (6%) (TEX Report, The, 2011a, b).

Chinese export tariffs in 2010 for ferrosilicon and silicon metal remained at 25% and 15%, respectively (Metal-Pages, 2011). With these duties, the Chinese Government aimed to reduce exports of these materials from the country so more material would be available for the domestic market.

The Central Government of China imposed electricity and CO_2 emission restrictions on energy-intensive industries in the fourth quarter of 2010; CO_2 emissions were to be reduced by 20%. Electricity supply on the national grid was cut mainly in the so-called Silicon Land—the area comprised of Gansu Province, Inner Mongolia Autonomous Region, Ningxia Hui Autonomous Region, and Qinghai Province. As a result, Chinese ferrosilicon and silicon metal production fell, and spot-market prices rose sharply at the end of the year (TEX Report, The, 2011c, d).

France.—In late March, Grupo FerroAtlántica S.L. (Ferroatlantica) restarted production at its five French silicon plants as aluminum and chemical market conditions improved. The plants included the following with their associated products and capacities: Anglefort, silicon metal (36,000 t/yr); Château Feuillet, silicon metal (12,000 t/yr); Laudun, ferrosilicon (25,000 t/yr) and silicon (14,000 t/yr); Les Clavaux, silicon metal (35,000 t/yr); and Montricher, silicon metal (30,000 t/yr) (Metal-Pages, 2010b).

Kazakhstan.—Eurasian Natural Resources Corp. PLC produced 48,000 t of ferrosilicon in 2010 at its Aksu plant in Kazakhstan and its Serov plant in Russia (Eurasian Natural Resources Corp. PLC, 2010a, p. 13; b, p. 12; c, p. 6; 2011, p. 6).

Macedonia.—Ownership in the Silmak dooel silicon materials plant located in Jegunovce changed twice during 2010. In February, Paris-registered metal trader Société Commerciale de Métaux et Mineraux sold the plant to Metal Invest EFT, the Macedonian unit of international energy trading company The EFT Group. Metal Invest then sold 90% of the plant to Hong Kong-based Camelot Group in July. The plant, renamed Jugohrom Ferroalloys, resumed ferrosilicon production in July at a rate of 4,500 metric tons per month (t/mo) with the restart of four of its eight ferrosilicon furnaces; the plant had been shut down since early November 2009. The company was reportedly upgrading the remaining four ferrosilicon furnaces to produce silicon metal (Metal-Pages, 2010e; SeeNews, 2010).

Norway.—Norwegian producers of silicon-materials ramped-up production considerably during 2010 in response to improved market conditions and low inventories. Fesil AS reported full capacity utilization at its two-furnace Rana Metall ferrosilicon plant after May. The Rana Metall ferrosilicon plant production capacity was 90,000 t/yr. Fesil held majority interest (51%) in Fesil Sunergy AS, which started construction in 2010 on a fully financed UMG-Si pilot plant at Fesil's idled Lilleby silicon-materials plant. Fesil Sunergy's goal would be to produce 6,800 t/yr of UMG-Si (Fesil AS, 2011, p. 3–4, 10, 20).

By the third quarter, Finnfjord Smelteverk was operating all three furnaces, up from two in 2009, at its 100,000-t/yr ferrosilicon plant near Finnsnes. Virtually all of Finnfjord's production was exported to the European Union. Construction also began on Finnfjord's energy-recovery plant to capture waste heat from its ferrosilicon furnaces. The energy the company would save, estimated to be 340 gigawatt-hours, would be equivalent to the annual electricity requirements of 12,000 single family homes (Metal-Pages, 2010d; Norske Energi, 2011, p. 4).

Orkla ASA (2010, p. 6) reported its Elkem AS silicon-related businesses were operating at close to full capacity by the end of September. In the third quarter of 2010, average capacity utilization was 91% compared with 57% in the third quarter of 2009. Elkem had total ferrosilicon production capacity of 76,000 t/yr; 40,000 t/yr at the Bjolvefossen plant and 36,000 t/yr in Bremanger. Elkem's silicon metal capacity was as follows: Salten, 65,000 t/yr; Thamshavn, 40,000 t/yr; and Bremanger, 28,000 t/yr.

German chemical producer Wacker Chemie AG acquired the 50,000-t/yr Holla Metall silicon metal plant from Fesil in June for €66.5 million ($80 million). As a result, the plant would supply Wacker with one-third of its annual silicon metal needs, and up to 20% of silicon metal would be removed from the European spot market (American Metal Market, 2010b; Wacker Chemie AG, 2011, p. 2).

Poland.—In March, Poland's sole ferrosilicon producer Huta Laziska doubled production to 5,000 t/mo to meet increasing iron and steel industry requirements. The company's total ferrosilicon production capacity was 96,000 t/yr (Metal-Pages, 2010a).

Russia.—Russia exported 412,892 t of ferrosilicon in 2010, an increase of 30% from that in 2009. This was an alltime high for the country, as Russian producers filled the void left by a decrease in Chinese ferrosilicon exports to Europe and Asia. The leading destinations for Russian ferrosilicon exports were the Netherlands (115,822 t), Japan (103,372 t), and the Republic of Korea (76,639 t) (TEX Report, The, 2011e, f).

Mechel OAO reported an increase in ferrosilicon production at its Bratsk ferroalloys plant in Eastern Siberia to 89,920 t in 2010 from 86,010 t in 2009. The company planned to increase the plant's ferrosilicon production capacity to 122,000 t/yr from 87,200 t/yr by 2013 (Mechel OAO, 2011, p. 104–105, 107).

Spain.—During the year, Ferroatlantica operated only one furnace at reduced capacity at its Sabon silicon metal plant. The Sabon plant had a total production capacity of 40,000 t/yr (Metal Pages, 2010c).

Ukraine.—Ferrosilicon production in the Ukraine increased by 30% to 195,500 t from 150,300 t in 2009. Stakhanov Ferroalloy Works produced 136,100 t of ferrosilicon, up 22.6% from that of 2009, and Zaporizhiya Ferroalloy Works produced 59,400 t of ferrosilicon, up 51% from that of 2009 (Interfax Russia & CIS Metals & Mining Weekly, 2011).

Outlook

Domestic and global consumption for ferrosilicon was expected to follow closely the trend in steel production, for which the annual growth rate has been typically in the range of 1% to 2% in the United States. Details of the outlook for the steel industry are discussed in the Outlook section of the Iron and Steel chapter of the 2010 USGS Minerals Yearbook, volume I, Metals and Minerals. According to the World Steel Association (2011), raw steel production, compared with that in 2009, increased by 38.5% to 80.6 Mt in the United States and by 15% worldwide to slightly more than 1.4 billion metric tons (Gt). Raw steel production in China, the leading world producer of raw steel, increased by 9.3% to about 627 Mt. MEPS (International) Ltd. (2011) forecast world raw steel production would increase by 5% to 1.49 Gt in 2011 from that in 2010, and then by 4.4% in 2012.

Demand for silicon metal comes primarily from the aluminum and chemical industries. Consumption of silicon metal by the U.S. aluminum castings industry was expected to mirror the short-term growth rate of 14.9% from 2010 through 2013 in aluminum casting sales, and the long-term growth rate of 10.9% from 2010 through 2019 (Modern Casting, 2011). U.S. chemical production was expected to increase by 3% in 2011 (by 2.7% when excluding pharmaceuticals) compared with that in 2010. Deloitte LLP forecast that China would overtake the United States as the world's largest chemical market in 2011 (Bomgardner, 2011a, b).

World production capacity for polycrystalline silicon can be used as a rough indicator of ultrahigh-purity silicon consumption. Compared with the revised amount of 95,000 t in 2009, world polycrystalline silicon output increased by 53% to 145,000 t in 2010. Of that amount, the solar cell market accounted for 83% and the semiconductor market 17%. World production capacity for polycrystalline silicon was forecast to increase by 30% to 213,600 t in 2011 from that in 2010; by 2013, world polycrystalline silicon production capacity would increase to 242,600 t (Roskill's Letters from Japan, 2010a, p. 3; b, p. 1, 4).

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TABLE 1

SALIENT SILICON STATISTICS[1]

(Contained silicon, unless otherwise noted)

		2006	2007	2008	2009	2010
United States:						
Production:						
Ferrosilicon	thousand metric tons	146	155	180	139	176
Silicon metal	do.	W	W	W	W	W
Exports:						
Ferrosilicon	do.	5	7	10	9	15
Silicon metal	do.	27	28	35	38	65
Imports for consumption:						
Ferrosilicon	do.	223	208	190	70	157
Silicon metal	do.	146	147	168	113	171
Apparent consumption:						
Ferrosilicon	do.	363	359	352	207 r	312
Silicon metal	do.	W	W	W	W	W
Price, average:						
Ferrosilicon, 50% Si[2]	cents per pound	62.93	73.96	115.86	76.93	109.33
Ferrosilicon, 75% Si[3]	do.	54.87	65.62	108.71	68.91	97.18
Silicon metal[4]	do.	79.29	112.69	162.29	116.37	140.05
World production, gross weight:						
Ferrosilicon	thousand metric tons	6,410 r	7,310 r	7,430 r	7,320 r	7,890
Silicon metal[5]	do.	1,490 r	1,600 r	1,680 r	1,790 r	2,180

rRevised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Ryan's Notes North American transaction prices based on weekly averages.

[3] Platts Metals Week mean import prices based on monthly averages.

[4] Platts Metals Week dealer import prices based on monthly averages.

[5] Excluding the United States.

TABLE 2
PRODUCTION, SHIPMENTS, AND STOCKS OF SILICON ALLOYS AND METAL IN THE UNITED STATES[1,2]

(Metric tons)

	Silicon content (percent)		2009	2010		
Material	Range	Typical	Producers' stocks, December 31 (gross weight)	Gross production[3] (gross weight)	Net shipments (gross weight)	Producers' stocks, December 31 (gross weight)
Ferrosilicon[4]	25–65 [5]	48	11,000 [r]	153,000	113,000	12,700
Do.	56–95	76	11,300 [r]	135,000	138,000	18,300
Silicon metal, excluding semiconductor grades	96–99	98	W	W	W	W

[r] Revised. Do. Ditto. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Data for silvery pig iron (less than 25% silicon) withheld to avoid disclosing company proprietary data.

[3] Ferrosilicon production includes material consumed in the production of miscellaneous silicon alloys.

[4] Includes miscellaneous silicon alloys.

[5] 25% to 55% for ferrosilicon; 32% to 65% for miscellaneous silicon alloys.

TABLE 3
PRINCIPAL PRODUCERS OF SILICON ALLOYS AND (OR) SILICON METAL IN THE UNITED STATES IN 2010

Producer	Plant location	Product
CC Metals and Alloys, Inc.	Calvert City, KY	Ferrosilicon.
Globe Metallurgical, Inc.[1]	Alloy, WV	Ferrosilicon and silicon metal.
Do.	Beverly, OH	Do.
Do.	Niagara Falls, NY	Silicon metal.
Do.	Selma, AL	Do.
Core Metals Group[2]	Bridgeport, AL	Ferrosilicon.
Simcala, Inc.[3]	Mt. Meigs, AL	Silicon metal.

Do. Ditto.

[1] Owned by Globe Specialty Metals, Inc. (GSM).

[2] Acquired by GSM in April 2010.

[3] Owned by Dow Corning Corp.

TABLE 4
REPORTED CONSUMPTION, BY END USE, AND STOCKS OF SILICON FERROALLOYS AND METAL IN THE UNITED STATES IN 2010[1, 2]

(Metric tons, gross weight)

End use	Silvery pig iron[3]	Ferrosilicon, 50%[4]	Ferrosilicon, 75%[5]	Silicon metal[6]	Miscellaneous silicon alloys[7]	Silicon carbide[8]
Steel:						
Carbon and high-strength, low-alloy	(9)	(10)	35,700	(11)	1,490	(10)
Stainless and heat-resisting	--	(10)	46,300	285	(10)	(10)
Full alloy	--	5,070	7,980	(11)	(10)	--
Electric and tool	--	--	(10)	--	--	(10)
Unspecified	--	24,400	20,100	(11)	456	5,910
Total	--	29,400	110,000	285	1,940	5,910
Cast irons	4,540	25,700	22,900	(11)	14,300	20,800
Superalloys	--	(9)	(11)	(11)	(9)	--
Alloys, excluding superalloys and alloy steel	(9)	(9)	(11)	52,200 [12]	--	--
Miscellaneous and unspecified	--	(9)	922	176,000 [13]	(9)	(9)
Grand total	4,540	55,100	134,000	228,000	16,300	26,700
Consumers' stocks, December 31	359	1,110	9,050	2,200	783	740

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes U.S. Geological Survey estimates.

[3] Typically 18% silicon content but ranges between 5% to 24% silicon content.

[4] Typically 48% silicon content but ranges between 25% to 55% silicon content; includes briquets.

[5] Typically 76% silicon content but ranges between 56% to 95% silicon content; includes briquets.

[6] Typically 98% silicon content but ranges between 96% to 99% silicon content.

[7] Typically 48% silicon content. Primarily magnesium-ferrosilicon but also includes other silicon alloys.

[8] Typically 64% silicon content but ranges between 63% to 70% silicon content. Does not include silicon carbide for abrasive or refractory uses.

[9] Included with "Cast irons," to avoid disclosing company proprietary data.

[10] Included with "Steel: Unspecified," to avoid disclosing company proprietary data.

[11] Included with "Miscellaneous and unspecified," to avoid disclosing company proprietary data.

[12] Primarily aluminum alloys.

[13] Primarily silicones, fumed silica, and other chemicals.

TABLE 5
U.S. EXPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2010[1, 2]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Ferrosilicon:			
More than 55% silicon:			
Brazil	550	333	$983,000
Canada	14,000	8,430	9,330,000
Ecuador	78	59	109,000
Germany	40	31	58,900
Italy	65	50	128,000
Japan	138	104	286,000
Mexico	1,870	1,140	3,820,000
Netherlands	1,750	1,250	2,990,000
Turkey	43	28	91,400
United Kingdom	107	75	113,000
Other (12 countries)	148	105	306,000
Total	18,800	11,600	18,200,000
Other ferrosilicon:			
Belgium	356	165	639,000
Canada	1,550	773	1,840,000
Colombia	94	43	149,000
Japan	841	419	1,430,000
Korea, Republic of	648	288	621,000
Luxembourg	139	71	117,000
Mexico	2,040	941	4,810,000
Netherlands Antilles	63	31	169,000
Turkey	480	216	905,000
United Kingdom	110	49	197,000
Other (12 countries)	270	115	538,000
Total	6,590	3,110	11,400,000
Total ferrosilicon	25,400	14,700	29,600,000
Metal:			
More than 99.99% silicon:			
China	19,500	XX	910,000,000
France	339	XX	15,200,000
Germany	5,670	XX	256,000,000
Hong Kong	683	XX	23,900,000
Japan	10,000	XX	635,000,000
Korea, Republic of	2,450	XX	168,000,000
Norway	5,240	XX	269,000,000
Singapore	1,650	XX	107,000,000
Taiwan	3,270	XX	181,000,000
Ukraine	288	XX	13,700,000
Other (55 countries)	838	XX	80,200,000
Total	49,900	49,900[e]	2,660,000,000
99.00%–99.99% silicon:			
Belgium	169	168	320,000
Egypt	300	297	825,000
Germany	927	919	2,690,000
Indonesia	135	133	190,000
Israel	50	50	90,000
Japan	1,180	1,170	3,210,000
Mexico	83	83	149,000
Singapore	149	147	209,000
Spain	43	42	107,000
United Kingdom	111	110	271,000

See footnotes at end of table.

TABLE 5—Continued
U.S. EXPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2010[1, 2]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Metal—Continued:			
99.00%–99.99% silicon—Continued:			
Other (19 countries)	184	182	$327,000
Total	3,330	3,300	8,390,000
Other silicon:			
Canada	2,250	2,180	6,840,000
China	351	341	569,000
Germany	64	62	248,000
Hong Kong	1,030	1,000	1,570,000
Japan	7,650	7,380	20,600,000
Mexico	434	421	712,000
South Africa	57	56	115,000
Taiwan	246	235	1,830,000
United Arab Emirates	52	50	152,000
United Kingdom	264	259	474,000
Other (20 countries)	210	204	576,000
Total	12,600	12,200	33,700,000
Total silicon metal	65,900	65,400	2,700,000,000

[e] Estimated. XX Not applicable.

[1] Countries listed are the leading exporters in terms of year-to-date quantities (gross weight).

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2010[1, 2]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Ferrosilicon:			
55%–80% silicon, more than 3% Ca:			
Argentina	113	76	$256,000
Brazil	1,640	987	4,010,000
Canada	1	1	2,680
China	1,570	1,150	2,020,000
France	1,030	667	2,620,000
Israel	38	23	82,000
Norway	15	10	44,500
Total	4,410	2,910	9,040,000
55%–80% silicon, other:			
Brazil	1,340	1,020	2,300,000
Canada	11,300	8,340	23,700,000
China	41,600	31,500	57,300,000
France	1,800	1,320	4,930,000
Germany	709	520	3,500,000
Hong Kong	500	375	855,000
India	323	238	844,000
Norway	219	163	644,000
Russia	108,000	82,600	159,000,000
Venezuela	23,200	14,400	38,300,000
Other (3 countries)	173	117	612,000
Total	189,000	144,000	292,000,000
80%–90% ferrosilicon, Germany	186	151	311,000
Magnesium ferrosilicon:			
Argentina	566	225	1,500,000
Brazil	1,630	736	2,710,000
Canada	11,300	5,110	20,100,000
China	395	180	736,000
France	525	220	774,000
Japan	31	14	125,000
Norway	5	2	17,300
South Africa	19	8	18,900
Total	14,500	6,500	26,000,000
Other ferrosilicon:			
Brazil	35	16	13,700
Canada	6,990	1,730	8,450,000
China	13,600	1,960	7,050,000
France	9	5	22,500
Singapore	4	2	7,170
Total	20,700	3,710	15,500,000
Total ferrosilicon	229,000	157,000	342,000,000
Metal:			
More than 99.99% silicon:			
Brazil	56	XX	8,950,000
Canada	363	XX	6,990,000
China	151	XX	6,240,000
Germany	2,530	XX	166,000,000
Italy	295	XX	20,500,000
Japan	468	XX	46,200,000
Korea, Republic of	628	XX	35,100,000
Norway	256	XX	8,470,000
Russia	55	XX	3,980,000

See footnotes at end of table.

TABLE 6—Continued
U.S. IMPORTS OF FERROSILICON AND SILICON METAL, BY GRADE AND COUNTRY, IN 2010[1, 2]

Country	Gross weight (metric tons)	Contained weight (metric tons)	Value
Metal—Continued:			
More than 99.99% silicon—Continued:			
Taiwan	46	XX	$3,260,000
Other (11 countries)	26	XX	4,140,000
Total	4,870	4,870 e	309,000,000
99.00%–99.99% silicon:			
Australia	10,900	10,900	29,200,000
Brazil	64,800	63,400	172,000,000
Canada	7,490	7,330	20,000,000
France	1,280	1,280	4,320,000
Laos	7,280	7,250	15,300,000
Norway	8,300	8,250	31,800,000
Philippines	436	433	1,020,000
South Africa	33,800	33,600	83,500,000
Spain	2,420	2,410	6,340,000
Thailand	3,490	3,480	7,930,000
Other (9 countries)	426	141	1,020,000
Total	141,000	138,000	372,000,000
Other silicon:			
Australia	240	237	727,000
Brazil	10,100	9,840	19,800,000
Canada	12,200	11,900	29,000,000
China	353	220	767,000
France	2,710	2,650	6,680,000
Germany	156	43	199,000
Japan	282	228	759,000
Norway	2,650	2,060	6,890,000
Philippines	205	202	492,000
Sweden	148	108	186,000
Other (5 countries)	193	168	436,000
Total	29,200	27,600	66,000,000
Total silicon metal	175,000	171,000	748,000,000

[1] Presentation of monthly data is based on the year-to-date quantities (gross weight) of the leading countries.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 7
SILICON MATERIALS: FINAL ANTIDUMPING DUTY RATES ASSESSED IN 2010[1]

(Listed in order of date assessed)

Date	Imported material	Country of origin	Period of investigation	Producer and duty rate
January 12	Silicon metal	China	6/1/07–5/31/08	All imports (139.49%), except those from: Jiangxi Gangyuan (50.02%) and Shanghai Jinneng (23.16%)
March 29	Do.	do.	6/1/05–5/31/06	Jiangxi Gangyuan (71.57%) and Shanghai Jinneng (50.41%)
April 21	Do.	Brazil	7/1/96–6/30/97	Eletrosilex S.A. (67.93%)

Do., do. Ditto.

[1] Antidumping duties are assessed by the International Trade Commission.

Source: Federal Register notices, unless otherwise noted.

TABLE 8

SILICON MATERIALS: APPEALS OF IMPORT ANTIDUMPING DUTY ADMINISTRATIVE REVIEWS IN 2010, BY DECISION DATE

Imported material	Country of origin	Period of investigation	U.S. court	Decision	Decision date	Source
Silicon metal	China	6/1/06–5/31/07	CIT	Upheld ITC's remand determination of April 8, 2010, that an administrative review was not the proper venue to pursue silicon metal transshipment allegations against Canadian distributor Ferro-Alliages et Mineraux. Ferro-Alliages was suspected of transshipping Chinese silicon metal through Canada into the United States to circumvent U.S. antidumping duties on Chinese silicon metal imports. ITC found no evidence that Ferro-Alliages exported any silicon metal into the the United States during the period of investigation and therefore no further review of the company was warranted.	September 1	Globe Metallurgical Inc. v. United States, Court No. 08–00290, CIT Slip Opinion 10–100.

CIT, Court of International Trade. ITC, International Trade Commission.

TABLE 9
SILICON MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2014[1, 2, 3, 4]

(Metric tons, gross weight, unless otherwise specified)

Projected year of first production	Country	Project and company	Project type	Incremental annual production capacity	Total annual production capacity	Silicon product[5]
2010	China	ERDOS Qipanjing Plant ERDOS Group	ferroalloys plant expansion	100,000	650,000	FeSi.
2010	Do.	Henan Sunshine Silicon Plant Henan Sunshine Silicon Technology Development	silicon plant expansion	80,000	120,000	Si.
2010	Do.	Qinghai Wutong Plant Qinghai Wutong (Group) Industry Co., Ltd.	ferroalloys plant expansion	25,000	400,000	FeSi.
2010	Kazakhstan	Silicium Kazakhstan Silicon Plant Silicium Kazakhstan LLP	silicon plant expansion	12,500	25,000	Si.
2010	Russia	Yurga Plant JSC[6] Kuznetsk Ferroalloys	do.	19,500	41,400	FeSi.
2010	Thailand	Ratchaburi Silicon Plant G.S. Energy Co., Ltd.	new silicon plant	NA	25,000	Si.
2011	Australia	Simcoa Silicon Plant Simcoa Operations Pty., Ltd.	silicon plant expansion	16,000	48,000	Do.
2011	China	ERDOS Qipanjing Plant ERDOS Group	ferroalloys plant expansion	350,000	1,000,000	FeSi.
2011	Do.	Ferroatlantica Sichuan Silicon Plant Grupo FerroAtlántica, S.L.	new silicon smelter	NA	50,000	Si.
2011	Do.	Qinghai Wutong Plant Qinghai Wutong (Group) Industry Co., Ltd.	ferroalloys plant expansion	25,000	450,000	FeSi.
2011	Kazakhstan	Silicium Kazakhstan Silicon Plant Silicium Kazakhstan LLP	silicon plant expansion	12,500	37,500	Si.
2011	Russia	Yurga Plant JSC[6] Kuznetsk Ferroalloys	do.	41,400	80,000	FeSi.
2011	Thailand	Ratchaburi Silicon Plant G.S. Energy Co., Ltd.	do.	20,000	45,000	Si.
2012	Australia	Simcoa Silicon Plant Simcoa Operations Pty., Ltd.	do.	16,000	64,000	Do.
2012	China	ERDOS Qipanjing Plant ERDOS Group	ferroalloys plant expansion	1,000,000	2,000,000	FeSi.
2012	Kazakhstan	Ekibastuz Silicon Plant Pohang Iron and Steel Company (POSCO, 60%) and Zaman Group (40%)	new ferrosilicon aluminum smelter plant	NA	45,000	FeSiAl.
2012	Zambia	Kafue Ferroalloys Plant Universal Mining and Chemical Industries Ltd. (Umcil)	new ferroalloys plant[7]	NA	80,000	FeSi.
2013	China	Ferroatlántica Sichuan Silicon Plant Grupo FerroAtlántica, S.L.	silicon plant expansion	50,000	100,000	Si.
2013	Iceland	Icelandic Silicon Corporation Plant Globe Specialty Metals (85%) and Tomhawk Development (15%)	new silicon smelter	NA	40,000	FeSi.
2013	Russia	Bratsk Ferroalloy Plant Mechel OAO	ferroalloys plant expansion	34,800	122,000	Do.
2013	Do.	Chelyabinsk Electrometallurgical Integrated Plant Chelyabinsk Group	do.	300,000	500,000 e	Do.
2013	Do.	Yurga Plant JSC[6] Kuznetsk Ferroalloys	ferroalloys plant expansion	70,000	150,000	Do.

See footnotes at end of table.

TABLE 9—Continued

SILICON MATERIALS: PROJECTS SCHEDULED FOR COMPLETION, BY YEAREND 2014[1, 2, 3, 4]

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[e] Estimated. Do., do. Ditto. NA Not available.

[1] Estimated data are rounded to no more than three significant digits.

[2] Excludes silicon metal containing more than 99.99% silicon.

[3] Projects in feasibility or later stages of development in 2010. Actual startup dates may be postponed, owing to economic or other factors. Additional projects might produce silicon materials by 2014, but not enough information was available to include them.

[4] No projects were scheduled for startup in 2014.

[5] FeSi Ferrosilicon. FeSiAl Ferrosiliconaluminum. Si Silicon metal (containing 99.99% or less Si).

[6] JSC joint-stock company.

[7] Plant also scheduled to produce ferromanganese and silicomanganese. Plant may also produce ferronickel.

Sources: Company annual reports, presentations, and press releases; unpublished personal communications; and trade publications.

SILVER

By William E. Brooks

Domestic survey data and tables were prepared by Jesse J. Inestroza, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, the United States produced 1,280 metric tons (t) of silver, which was slightly more than the 2009 domestic silver production, and accounted for approximately 6% of world mine production of 23,100 t of silver. Silver was produced in 11 States in 2010, and Alaska remained the country's leading silver-producing State, followed by Nevada and Idaho. Approximately 99% of domestic silver was produced from base-metal ores at 11 mines and from precious-metal ores at 14 mines.

The Handy & Harman price of silver averaged $20.20 per troy ounce in 2010, a 37% increase compared with the 2009 average price of $14.69 (table 1). The price of silver peaked at $30.64 per troy ounce on December 31, but was still below the high price of $50.35 per troy ounce in 1980. Increased use of silver for industrial applications and investor interest in silver owing to financial instability worldwide and the relatively low price of silver compared with that of gold were important factors in the increased silver price.

Traditional use categories for silver included coin and medal fabrication; industrial applications, including electrical and electronics components; jewelry and silverware; and photography. In 2010, the global use of silver for photographic applications continued to decline and the use of silver for jewelry and silverware increased slightly. The use of silver in electronics and industrial applications increased in 2010 owing to silver's biocidal and conductive properties. Silver is used in electronics applications, including flat-screen televisions and radio-frequency identification devices (RFIDs), which are used in barcodes, some high-denomination casino chips, passports, and speedpasses. Nanosilver (silver particles in the range of 1 to 100 nanometers) was widely used in food packaging, medical applications, and textiles. Global minting of bullion coins increased in 2010 owing to the surge in investment-related coin purchases; especially in the United States and Europe. The U.S. Mint led the way with a 21% increase to 1,300 t of silver used in 2010 from 1,100 t in 2009, and the global use of silver for coin and medal fabrication increased to 3,150 t in 2010 from 2,460 t in 2009 (Silver Institute, The, 2011, p. 23).

U.S. imports for consumption of refined silver in 2010 increased by 58% compared with those in 2009. U.S. exports of silver bullion increased to 523 t in 2010 compared with 167 t exported in 2009. In 2010, Mexico was the leading source of imported refined silver into the United States, followed by Canada, the United Kingdom, and Poland. Mexico was the leading destination for exported silver, followed by Canada, Australia, and Germany. In 2010, silver was mined in approximately 65 countries; global production was slightly higher than that in 2009, and Mexico was the leading producer, followed by Peru, China, and Australia. The United States ranked seventh in world silver mine production in 2010.

Legislation and Government Programs

On September 30, 2010, the amount and value of Deep Storage and Working Stock custodial silver reserves in the U.S. Mint were 498,000 kilograms (kg) of silver with a total market value of $353 million at $22.07 per fine troy ounce and a statutory value of $20.7 million. As custodian, the U.S. Mint is responsible for safeguarding much of the Nation's gold and silver. In accordance with 31 U.S. Code section 5117 (b) and 31 U.S. Code section 5116 (b) (2), a statutory rate of no less than $1.292929292 per fine troy ounce was used to value the custodial silver held by the U.S. Mint (U.S. Mint, 2011, p. 59). The U.S. Mint's six facilities are in Denver, CO; Fort Knox, KY; Philadelphia, PA; San Francisco, CA; Washington, DC; and West Point, NY.

Production

Domestic mine production data was solicited from 36 operations. Of these operations, 33 responded to the U.S. Geological Survey (USGS) canvass, representing 100% of U.S. mine production listed in table 1. Domestic mine production of silver totaled 1,280 t in 2010, which was slightly more than that in 2009.

Silver in the United States was mainly produced as a byproduct from gold and base-metal ores, although silver was produced as a principal product at Coeur d'Alene Mines Corp.'s (Coeur d'Alene, ID) Rochester Mine, near Winnemucca, in northwestern Nevada. Coeur announced preparations to mine new ore zones at Rochester that were expected to extend mine life by 6 years and produce an average of 78 metric tons per year (Coeur d'Alene Mines Corp., 2010b). However, silver production decreased at the Rochester Mine by 7%, to 63 t in 2010 from 68 t in 2009 (Coeur d'Alene Mines Corp., 2011, p. 7).

Increased silver prices in 2010 generated increased mining interest. For example, in the Silver Valley, ID, United Mining Group (UMG) (Vancouver, British Columbia, Canada) announced that at its Crescent silver mine, it was completing a new portal and rehabilitating sections of the Hooper tunnel, which was expected to provide access to the south vein (United Mining Group, 2010b). The company completed a claims purchase agreement to increase its contiguous land holdings in the Silver Valley (United Mining Group, 2010a). The Crescent Mine had been closed more than a dozen years ago when the price of silver was $5 per troy ounce (Cui and Matthews, 2010).

Silver production at Kennecott Utah Copper Corp.'s (a subsidiary of Rio Tinto plc, London, United Kingdom) Bingham Canyon Mine in Utah decreased by 23% owing to a 20% decrease in silver grade (Silver Institute, The, 2011, p. 25). At Teck Resources Ltd.'s (Vancouver) Red Dog Mine in Alaska, silver production decreased by 15% owing to the impact of lower grades and recoveries, a direct result of processing weathered ore from the Aqqaluk deposit (Silver Institute, The, 2011, p. 25). However, Teck's silver production from all its mines rose by 23%, and Teck provided the gold, silver, and copper, which included recycled metals reclaimed from e-waste, that were used to produce the medals awarded at the 2010 Winter Olympic Games (Teck Resources, Ltd., 2011, p. 16).

In 2010, Hecla Mining Co. (Coeur d'Alene, ID) produced silver from two mines, the Lucky Friday Mine in Idaho and the Greens Creek Mine in Alaska, which was the world's eighth leading silver mine. Production at Lucky Friday decreased by 5% in 2010 compared with that of 2009, and production at Greens Creek Mine decreased slightly compared with that of 2009 (Hecla Mining Co., 2011). U.S. Silver Corp. (Toronto, Ontario, Canada) produced 71 t of silver in 2010, a 5% decrease compared with 2009 silver production of 75 t. The company indicated that the decrease was owing to mining of lower grade ore (U.S. Silver Corp., 2011).

New Jersey Mining Co. (Kellogg, ID) started shipping ore from its Silver Strand Mine, in the Silver Valley, ID, in May and began processing the ore in June (New Jersey Mining Co., 2010b). The company also announced a joint venture with Marathon Gold Corp. (Toronto), which resulted in the formation of Golden Chest LLC (New Jersey Mining Co., 2010a). New Jersey also planned to expand its flotation mill in Kellogg, ID, in order to process silver ore from the nearby Crescent Mine, which was owned by UMG, as well as ore from the New Jersey's mine. New Jersey had an agreement with UMG in which UMG would pay $2.3 million in costs and process 10,000 metric tons per month of silver ore (New Jersey Mining Co., 2011).

Revett Minerals Inc. (Spokane Valley, WA) announced that a 950-meter (m) ramp, which was initiated in February 2010 and provided access to the "C-Bed" area of its Troy Mine, in northwestern Montana, had been completed on time and on budget. Limited output from the C-Bed area began in September, and more ore was included in the production mix at the beginning of the fourth quarter. Approximately 60 t of silver was in the C-Bed reserves (Revett Minerals Inc., 2010). The company announced record mill throughput of 1.3 million metric tons of ore in 2010 and production of 31 t of silver, an 11% decrease compared with 35 t of silver produced in 2009. Silver recovery was lower than that in 2009 owing to continued exploration of I-Bed targets beneath and adjacent to the existing mine, which temporarily reduced production. The mine life of Troy was extended by 7 years (Revett Minerals Inc., 2011).

The Montana Tunnels Mine, west of Jefferson City, MT, has produced gold, lead, silver, and zinc. The mine was purchased by Elkhorn Goldfields LLC (Denver, CO) from Apollo Gold Corp. (Denver, CO) in February 2010, and Montana Tunnels Mining Inc. became a 100%-owned subsidiary of Elkhorn Goldfields. The plan of operations for the L-Pit at the mine was completed in December 2008, and stockpiled ore was milled until April 2009, at which time all mine operations were placed on care-and-maintenance status (Elkhorn Goldfields LLC, 2010).

Consumption

Domestic consumption of silver increased by 14% and fabrication demand increased by 13% in 2010 compared with that of 2009; however, this was somewhat less than the overall 21% increase in the global consumption of silver during the same period (Silver Institute, The, 2011, p. 52).

Coin and Medal Fabrication.—Approximately 1,300 t of silver was used for coins and medals in the United States in 2010, a 21% increase from the 1,100 t of silver used in 2009 (Silver Institute, The, 2011, p. 23). The United States was the leading coin fabricator, and Silver Eagle bullion coin sales rose by 19% in 2010. Rationing of Eagle coin sales in the first three quarters of 2010 increased demand for Australia's Kookaburra, Koala, and Lunar coins; Austria's Philharmoniker coin; and Canada's Maple Leaf coin (Silver Institute, The, 2011, p. 23). The use of silver in circulating coins has been mostly phased out.

Industrial Applications.—Approximately 3,570 t of silver was used in the United States in 2010 for industrial applications, a 19% increase from the 3,000 t of silver that was used for those applications in 2009 (Silver Institute, The, 2011, p. 54). Owing to silver's electrical- and thermal-conducting properties, silver was used in conductors, contacts, fuses, switches, and timers. Other industrial applications of silver included uses in conductive adhesives; in the preparation of thick-film, silver-palladium pastes for use as silkscreen circuit paths in multilayer ceramic capacitors; in the manufacture of membrane switches; in food packaging; in flat-screen televisions with plasma display panels; in silver-backed solar mirrors; as a film in electrically heated automobile windows; in smart cards; and in photovoltaic cells. Silver consumption for photovoltaic cells increased to 1,500 t in 2010, an increase of 72% compared with consumption of 870 t in 2009. There are two types of photovoltaic cells—thick- and thin-film. Thick-film technology is silver intensive using 0.15 to 0.25 gram per cell, whereas silver use in thin-film cells is negligible. The leading solar-cell markets, in terms of installations, are in Germany and Italy (Silver Institute, The, 2011, p. 62). Solar markets are booming in the United States owing to consumer demand, rising energy prices, and financial incentives. More than 107,000 new solar cooling, electric, and heating installations were completed in 2009, an increase of 18% compared to the number of systems installed in 2008 and California remains the largest market in the United States (Sherwood, 2010). A small amount of silver was used as a miniature antenna in RFIDs, or radio frequency identification devices.

In 2010, other industrial applications for silver included its use in batteries, bearings, brazing and soldering, catalysts, disinfectants, mirrors, printed electronics, and water purification. Silver is also used as a coating material for compact disks and digital video disks. Dental amalgam, though in declining use because of its mercury content, may contain 34% to 38% silver (Lawrence, 1995). Owing to silver's antibacterial properties, silver was also used in classroom notebooks, clothing, dental amalgam, laundry machines, shoes, and toothbrushes. Silver embedded in locker room surfaces was used to reduce staph infections, and silver-based disinfectants have been introduced as a low-cost, environmentally sensitive option for use in care centers and food processing facilities.

Jewelry and Silverware.—In 2010, the U.S. demand for silver for jewelry and silverware was 400 t, an 11% increase compared with the 360 t used in 2009. World consumption of silver for jewelry and silverware increased slightly, to 6,760 t in 2010, from 6,750 t in 2009. Jewelry and silverware accounted for approximately 33% of fabrication demand a decade ago, however, this category now accounts for 25% of fabrication demand (Silver Institute, The, 2011, p. 68).

In 2010, the rise in gold prices caused jewelers to reduce the amount of gold in their products, in some cases using silver as a substitute. Other alternatives to gold in jewelry include cobalt, platinum, and tungsten (Pleven and Zimmerman, 2010).

Photography.—Silver was one of the essential materials used in the manufacture of films and photographic papers, and Eastman Kodak Co. (Rochester, NY) purchased silver from numerous suppliers. The decline in the use of silver for photography began in 2000 in response to digital camera technology and the decline in the production of color film and paper. Total net sales from Kodak's Film, Photofinishing, and Entertainment Group declined by 22%, to $1.8 billion in 2010 from $2.3 billion in 2009 (Eastman Kodak Co., 2011, p. 26). Domestic use of silver for photographic use declined by 14% to 630 t in 2010 from 730 t in 2009, and had declined by 71% compared with 2,180 t of silver used in 2000 (Silver Institute, The, 2011, p. 64).

The overall decline in silver use in the photographic industry was reflected in film sales. In 2010, 547 million rolls of silver-bearing film were sold globally, compared with 751 million rolls sold in 2009, a 27% decrease. World silver-bearing photographic paper consumption declined by 12%, to 850 million square meters in 2010 from 961 million square meters in 2009 (Silver Institute, The, 2011, p. 64). Other broad photographic-use categories included commercial photography, dental and industrial x rays, graphic arts, and medical x rays.

Prices and Stocks

In 2010, compilation of price data from Handy & Harman, and published in Platts Metals Week, indicated that the average price of silver was $20.20 per troy ounce (table 1). This price was 37% higher than the 2009 average price of $14.69 as indicated by Handy & Harman. On December 31, the price of silver listed by Handy & Harman peaked at $30.64 per troy ounce.

Global silver inventories in various Exchange Traded Funds (ETF) including iShares Silver Trust, ETF Securities, and other ETFs increased by 25%, to approximately 18,120 t at yearend 2010, compared with 14,540 t at yearend 2009 (Silver Institute, The, 2011, p. 100).

Global X Funds (New York, NY) opened its Global X Silver Miners Exchange Traded Fund, the only ETF in the world targeting silver mining companies. This ETF is focused on the performance of companies involved in silver exploration, mining, and refining and began trading on April 20 (Global X Funds, 2010b). In its first 2 weeks, Global X traded nearly 1 million shares and raised $35 million in assets (Global X Funds, 2010a).

In 2010, a five-member commission began investigations into allegations of price manipulation in the silver futures market in 2008. In October, at a hearing in Washington, DC, a commissioner of the Commodity Futures Trading Commission (CFTC) indicated that they had determined that there had been violations of the Commodity Exchange Act as well as repeated attempts to influence silver prices; the commissioner indicated that any violators would be prosecuted. The CFTC commissioner spoke at a hearing on the implementation of the Dodd-Frank Wall Street Reform and Consumer Protection Act, which became law in July (Loder and Nguyen, 2010).

Foreign Trade

U.S. imports of refined silver increased by 58%, to 5,680 t in 2010 from 3,590 t in 2009. Exports of refined silver increased by 200% to 714 t in 2010 from 356 t in 2009. In 2010, principal import sources of silver ores and concentrates, ash and residues, bullion, and dore were Mexico (2,580 t), Canada (1,590 t), and the United Kingdom (454 t) (table 6). Principal export destinations in 2010 were Mexico (220 t), Canada (105 t), and Australia (97 t) (table 4).

World Review

World mine production of silver was 23,100 t in 2010, a 5% increase from the revised 22,000 t of silver produced in 2009 (table 8). In Mexico, the world's leading silver-producing country in 2010, silver production increased by 24%, to 4,411 t in 2010 from 3,554 t in 2009. Silver production decreased in Peru (6%) and in China (21%), the world's second and third ranked silver producers, respectively. Regionally, in 2010, silver production increased in Oceania (mainly Australia) by 14%, to 1,880 t from 1,650 t in 2009 and in Africa by 11%, to 432 t from 390 t in 2009. According to data compiled by the Silver Institute (2011, p. 99), silver produced from primary silver mines increased by 5%, to 6,950 t in 2010 from 6,600 t in 2009; silver produced from gold mining decreased by 4%; silver produced from copper mining decreased by 3%; and silver supplied from lead/zinc mining increased by 5%.

Argentina.—Pan American Silver Corp. (Vancouver), the world's second leading primary silver producer, reported a 4% increase in silver production, to 123 t in 2010 from 118 t in 2009 at its Manantial Espejo Mine, in Santa Cruz. At Manantial Espejo, silver was produced at a cash cost of $1.63 per troy ounce. The company also completed an assessment for its world-class Navidad silver project, which contained 2,100 t of measured and indicated reserves (Pan American Silver Corp., 2011a).

Australia.—Silver production increased by 14% to 1,864 t in 2010 in from an 11-year low of 1,635 t in 2009. BHP Billiton's Cannington Mine became the world's leading producer of silver as a principal product in 2010. Output at Cannington was boosted by an 11% increase in head grade and a return to normal production levels following heavy rainfall and flooding that affected mine output in the first quarter of 2009 (Silver Institute, The, 2011, p. 29).

Bolivia.—Silver production decreased by 4% to 1,259 t in 2010 from 1,326 t in 2009 owing to production decreases at several operations (Silver Institute, The, 2011, p. 26). At Coeur d'Alene Mines Corp.'s San Bartolome Mine, production decreased by 9% to 210 t in 2010 from 230 t in 2009 (Coeur d'Alene Mines Corp., 2011, p. 11). Coeur also began mining silver-rich gravels which are above the 4,400 m level at San Bartolome (Coeur d'Alene Mines Corp., 2010a). Pan American Silver reported proven and probable reserves of 650 t of silver at its San Vincente Mine, and silver production increased by 15% to 94 t in 2010 from 82 t in 2009 (Pan American Silver, 2011a, b). Owing to a strike in August, production at Sumitomo Corp.'s (Tokyo, Japan) Minera San Cristobal S.A. Mine, in the Potosi District of southwestern Bolivia, decreased by 16% (Silver Institute, The, 2011, p. 28).

China.—Silver production from China, the world's third leading silver producer, increased by 21% to 3,500 t in 2010 from 2,900 t in 2009 (table 8). However, other information indicates that production may have increased by only 11% to 3,085 t in 2010 from 2,770 t in 2009 (Silver Institute, The, 2011, p. 24). Silver was produced mainly as a byproduct from copper or lead and zinc mining. Silvercorp Metals Inc. (Vancouver), the leading silver producer in China, has several silver-lead-zinc properties, projects, and mines in China and one property in northern British Columbia, Canada. The company produced 1,660 t of silver through the third quarter (December 31, 2010), an increase of 25% from production in the same period in 2009 (Silvercorp Metals, Inc., 2011).

Mexico.—In 2010, Mexico was the world's leading producer of silver, and silver production increased by 24% to 4,410 t from 3,550 t in 2009 (table 8). Fresnillo plc's (London, United Kingdom) namesake mine, in Zacatecas, was the second leading producer of silver after BHP Billiton's Cannington Mine in Australia (Silver Institute, The, 2011). Total Fresnillo silver production increased slightly to 1,310 t in 2010 from 1,280 t in 2009, mainly from the Fresnillo Mine in Zacatecas. (Fresnillo plc, 2011, p. 17). The Fresnillo Mine has produced silver for more than 450 years and mineralization is hosted in epithermal veins that were emplaced 29 to 30 million years ago in a Jurassic-Late Cretaceous volcaniclastic sequence (Velador and others, 2010). Coeur d'Alene Mines' Palmarejo Mine began production of gold and silver in the second quarter of 2009. Production at Palmarejo increased by 89% to 180 t in 2010 from 95 t in 2009 (Coeur d'Alene Mines Corp., 2011, p. 8).

Peru.—Peru was the world's second ranked silver producer in 2010. Three Peruvian mines, in order of decreasing production, Hochchild Mining's Pallancanta Mine, Compañia de Minas Buenaventura's Uchucchacua Mine, and Hochchild's Arcata Mine, are among the 10 leading silver mines in the world (Silver Institute, The, 2011, p. 24, 99). Peru's Ministry of Energy and Mines reported that Peru was the world leader in silver resources with reserves of more than 120,000 t of silver (Kosich, 2010). However, in 2010, overall production in Peru decreased by 6% to 3,640 t in 2010 from 3,854 t in 2009 (table 8). At Pan American Silver's Huraron Mine, production decreased by 16%; at the company's Morococha Mine, production decreased by 5%; and at the company's Quiruvilca Mine, production decreased by 13%. The overall Pan American decrease in 2010 was largely a result of lower silver grades, lower throughput, and lower recovery. In 2002, Pan American acquired the silver-rich pyrite stockpiles near Cerro de Pasco, and the ore had been shipped to the La Oroya smelter, where the ore was used as a process flux, and the silver was recovered. There was no silver production from Pan American's pyrite stockpiles in 2010, however, owing to closure of the La Oroya smelter, which had been the only buyer of this material (Pan American Silver, 2011a, p. 33). Production at Hochschild Mining plc's (London, United Kingdom) Pallancanta Mine increased by 19% to 310 t in 2010 from 260 t in 2009; however, production at the company's Arcata Mine decreased by 17% to 250 t in 2010 from 300 t in 2009, and production at the company's Ares Mine decreased by 14% to 24 t in 2010 from 28 t in 2009 (Hochchild Mining plc, 2011, p. 161). The decrease in the company's production was owing to geotechnical problems and a reduction in grades to extend mine life (Silver Institute, The, 2011, p. 27). Production also decreased at Compañia Minas Buenaventura's (Lima, Peru) Uchucchacua Mine, the world's sixth leading silver mine, by 12% to 290 t in 2010 from 330 t in 2009 owing to a worker strike and lower silver grades and recoveries (Silver Institute, The, 2011, p. 27, 99).

Outlook

World silver consumption increased by 15% to 32,900 t in 2010 from 28,700 t in 2009 (Silver Institute, The, 2011, p. 79) and investor interest in silver was overridden by the industrial demand for silver. The photovoltaic industry has emerged as a significant industrial-use sector for silver and was expected to become an even more substantial user of silver in the future. The use of silver in photographic application continues to decrease; however, this decrease has begun to level off as silver-containing paper was still used for high-quality paper prints from digital sources.

The use of RFIDs for tracking stocks and shipments, including silver-base high-data-capacity tags, readers, and computer systems, was expected to increase. Silver oxide batteries and conductive inks were increasingly being used in the electronics field. Owing to its antibacterial qualities, silver was expected to see increased use in medical applications. Nanoparticle silver is also expected to see increased use in industrial applications, and antimicrobial silver technology is expected to be used in keyboards, paper, pens, and telephones. Silver-based biocides were expected to be increasingly used and indicate a new generation of safe and environmentally friendly uses of silver for the control of bacterial, viral, and fungal infections, on hard surfaces and in water systems, and as a wood preservative. ETF inventories continued to increase year-on-year and indicated continued investor interest. Mine production increased owing to new projects in Argentina and Mexico.

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TABLE 1

SALIENT SILVER STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Mine production:						
Quantity	metric tons	1,160	1,280	1,250	1,250	1,280
Value	thousands	$431,000	$554,000	$600,000	$588,000	$829,000
Refinery production:						
Domestic and foreign ores and concentrates	metric tons	2,210	791	779	796	819
Scrap (old and new)	do.	1,110	1,130	1,210	1,340	1,340
Exports:						
Ore and concentrate	kilograms	3,150	15,800	130,000	122,000	82,100
Refined[2]	do.	1,670,000	781,000	555,000	356,000	714,000
Waste and scrap	metric tons	2,240	238	2,570	2,480	3,760
Imports for consumption:						
Ore and concentrate	kilograms	--	381	32	87	3,230
Refined	do.	4,830,000	4,980,000	4,680,000	3,590,000	5,680,000
Waste and scrap	do.	2,240,000	3,420,000	5,190,000	4,760,000	6,510,000
Stocks, December 31:						
Industry	metric tons	600 [r]	570 [r]	570 [r]	570 [r]	570
Futures exchanges	do.	3,460 [r]	4,120 [r]	3,980 [r]	3,480 [r]	3,260
U.S. Department of the Treasury	do.	220	220	220	220	220
Price, average[3]	dollars per troy ounce	11.57 [r]	13.41 [r]	15.00 [r]	14.69	20.20
Employment, mine and mill workers[4]		900	900	900	850	850
World, mine production	metric tons	20,100 [r]	20,800 [r]	21,400 [r]	22,000 [r]	23,100

[r] Revised. do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Includes refined bullion, dore, and other unwrought silver.

[3] Price data are the annual Handy & Harman quotations published in Platts Metals Week.

[4] Employment data are from the U.S. Department of Labor, Mine Safety and Health Administration.

TABLE 2

MINE PRODUCTION OF SILVER IN THE UNITED STATES, BY STATE[1]

(Kilograms)

State	2008	2009	2010
Nevada	235,000	203,000	224,000
Other[2]	1,020,000	1,040,000	1,050,000
Total	1,250,000	1,250,000	1,280,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Alaska, Arizona, California, Colorado, Idaho, Missouri, Montana, New Mexico, South Dakota, and Utah.

TABLE 3

LEADING SILVER-PRODUCING MINES IN THE UNITED STATES IN 2010, IN ORDER OF OUTPUT[1]

Rank	Mine	County and State	Operator	Source of silver
1	Red Dog	Northwest Arctic, AK	Teck Alaska Inc.	Zinc-lead ore.
2	Greens Creek	Juneau, AK	Hecla Mining Co.	Zinc-silver ore.
3	Bingham Canyon	Salt Lake, UT	Kennecott Utah Copper Corp.	Copper-molybdenum ore.
4	Lucky Friday	Shoshone, ID	Hecla Mining Co.	Silver ore.
5	Galena	do.	U.S. Silver Corp.	Do.
6	Mission Complex	Pima, AZ	ASARCO LLC[2]	Copper-molybdenum ore.
7	Rochester	Pershing, NV	Coeur d'Alene Mines Corp.	Silver ore.
8	Midas	Elko, NV	Newmont Mining Corp.	Gold ore.
9	Troy	Lincoln, MT	Revett Minerals Inc.	Copper-silver ore.
10	Bagdad	Yavapai, AZ	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore.
11	Hollister	Elko, NV	Great Basin Gold Ltd.	Gold ore.
12	Continental Pit	Silver Bow, MT	Montana Resources	Copper-molybdenum ore.
13	Smoky Valley Common Operation	Nye, NV	Kinross Gold Corp.	Gold ore.
14	Mineral Park	Mohave, AZ	Mercator Minerals Ltd.	Copper-molybdenum ore.
15	Denton-Rawhide	Mineral, NV	Rawhide Acquisition Holdings	Gold ore.
16	Carlin Mines Operations[3]	Elko, Eureka, Humboldt, Lander, NV	Newmont Mining Corp.	Do.
17	Hycroft	Humboldt and Pershing, NV	Allied Nevada Gold Corp.	Do.
18	Ray	Pinal, AZ	ASARCO LLC[2]	Copper ore.
19	Wharf	Lawrence, SD	Wharf Resources Inc.[4]	Gold ore.
20	Goldstrike	Elko and Eureka, NV	Barrick Gold Corp.	Do.
21	Morenci	Greenlee, AZ	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore.
22	Cresson	Teller, CO	AngloGold Ashanti Ltd.	Gold ore.
23	Brushy Creek	Reynolds, MO	Doe Run Resources Corp.	Lead ore.
24	Fletcher	do.	do.	Do.
25	Meikle	Elko, NV	Barrick Gold Corp.	Gold ore.

do., Do. Ditto.

[1] The mines on this list accounted for more than 99% of U.S. mine production in 2010.

[2] Wholly owned subsidiary of Grupo Mexico, S.A.B. de C.V.

[3] Includes Carlin East, Deep Post, Gold Quarry, Lone Tree, Mule Canyon, Pete, Rain/Emigrant, and Twin Creeks Mines.

[4] Wholly owned subsidiary of Goldcorp Inc.

TABLE 4
U.S. EXPORTS OF SILVER, BY COUNTRY[1]

	Silver ores and concentrates		Bullion		Dore		Total	
Year and country	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)
2009	122,000	$55,400	167,000	$93,600	130,000	$72,700	419,000 [r]	$222,000 [r]
2010:								
Argentina	--	--	12	8	3,780	1,940	3,790	1,950
Australia	29	10	97,300	65,700	--	--	97,300	65,700
Belgium	53	22	18	15	--	--	71	37
Brazil	--	--	--	--	789	324	789	324
Canada	220	99	104,000	74,800	--	--	105,000	74,900
China	--	--	9	4	150	63	159	67
Dominican Republic	946	515	--	--	--	--	946	515
Finland	--	--	--	--	243	108	243	108
Germany	15,800	9,560	33,000	23,100	21,100	7,810	69,900	40,500
Hong Kong	16	12	4,320	2,350	--	--	4,330	2,360
Ireland	337	80	514	229	--	--	851	309
Italy	--	--	43	24	557	228	600	252
Japan	--	--	38,600	30,400	--	--	38,600	30,400
Korea, Republic of	61,400	36,200	--	--	--	--	61,400	36,200
Malaysia	98	26	124	75	--	--	222	101
Mexico	1,170	684	218,000	115,000	60	24	220,000	115,000
Netherlands	--	--	86	52	--	--	86	52
New Zealand	127	86	221	132	1,920	774	2,270	992
Norway	210	104	36	21	2,650	1,170	2,890	1,290
Pakistan	--	--	418	176	--	--	418	176
Panama	--	--	--	--	645	264	645	264
Peru	--	--	233	98	620	266	853	364
Singapore	3	3	8,590	4,730	22,800	10,300	31,400	15,000
Switzerland	--	--	2,070	1,320	20,700	9,420	22,800	10,700
Taiwan	183	61	1,670	866	--	--	1,850	927
Thailand	--	--	86	56	--	--	86	56
United Kingdom	1,100	207	12,100	7,170	28,200	13,100	41,400	20,500
Vietnam	--	--	78	26	--	--	78	26
Other	415	103	334	259	113	48	862	410
Total	82,100	47,700	523,000	326,000	104,000	45,900	709,000	420,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5
U.S. EXPORTS OF SILVER, BY COUNTRY[1]

Year and country	Other unwrought silver		Metal powder		Silver nitrate		Semimanufactured forms[2]		Waste and scrap	
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
2009	59,000	$21,200	834,000	$434,000	27,900	$2,690	525,000	$252,000	2,480,000	$4,300,000
2010:										
Argentina	--	--	776	365	16	6	227	114	--	--
Australia	459	285	14	10	606	82	1,050	530	783	36,200
Austria	346	79	70	50	--	--	24	12	--	--
Bahrain	101	28	--	--	--	--	55	27	--	--
Belgium	52	11	6,430	3,870	39	6	2,430	1,080	707,000	167,000
Bolivia	183	34	--	--	--	--	37	18	--	--
Brazil	20	4	356	183	--	--	139	70	30	150
Canada	37,800	27,900	33,600	9,440	37,600	1,920	446,000	265,000	155,000	262,000
China	2,290	1,340	381,000	294,000	166	97	5,790	3,040	6,380	15,400
Costa Rica	549	448	--	--	1,340	455	40	23	--	--
Czech Republic	--	--	27	15	--	--	199	104	617	385
Denmark	11	12	--	--	--	--	12	6	4,090	2,980
Dominican Republic	1,200	501	75	50	143	67	699	353	67	31
Egypt	--	--	--	--	--	--	944	472	--	--
Estonia	--	--	--	--	--	--	273	138	--	--
Finland	--	--	250	65	--	--	10	8	--	--
France	76	28	82,000	50,200	--	--	8,580	4,680	15	76
Germany	860	247	82,000	54,600	591	124	10,700	5,850	983,000	223,000
Guatemala	933	598	--	--	--	--	72	51	--	--
Honduras	91	68	59	40	--	--	--	--	--	--
Hong Kong	11,500	6,830	28,500	23,600	--	--	16,100	8,410	1,660	3,240
India	19,300	6,860	--	--	20	6	13,800	7,030	78	274
Indonesia	1,440	916	--	--	58	11	81	46	--	--
Ireland	--	--	36	28	--	--	1,400	805	--	--
Israel	437	83	661	310	51	6	1,320	662	7	14
Italy	308	199	1,010	549	72	5	1,810	889	1,120,000	461,000
Japan	50	11	187,000	130,000	49	9	5,300	2,610	291,000	95,200
Jordan	--	--	--	--	--	--	211	105	--	--
Korea, Republic of	198	77	58,100	35,100	2	3	541	282	2,160	6,100
Malaysia	97	58	1,060	653	269	79	2,370	1,230	--	--
Mexico	1,480	574	4,730	2,210	10,500	1,400	70,100	36,100	443	1,140
Netherlands	14	3	21,600	14,500	--	--	44	37	253	1,350
New Zealand	23	8	--	--	113	12	232	117	--	--
Norway	62	16	--	--	--	--	67	35	--	--
Pakistan	--	--	--	--	--	--	206	103	5,890	3,340
Panama	193	66	--	--	--	--	176	88	15	577
Peru	15	3	--	--	642	23	--	--	--	--
Philippines	111	34	--	--	86	30	1,560	779	--	--
Russia	256	71	16	8	--	--	--	--	--	--

See footnotes at end of table.

TABLE 5—Continued

U.S. EXPORTS OF SILVER, BY COUNTRY[1]

Year and country	Other unwrought silver		Metal powder		Silver nitrate		Semimanufactured forms[2]		Waste and scrap	
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
2010—Continued:										
Saudi Arabia	--	--	--	--	--	--	1,650	$823	--	--
Singapore	259	$48	14,700	$7,860	--	--	4,470	2,030	2	$106
South Africa	5	3	--	--	48	$12	--	--	15,000	3,500
Spain	--	--	6	3	--	--	686	345	--	--
Suriname	--	--	--	--	402	37	--	--	--	--
Sweden	--	--	469	221	183	31	3,350	1,730	260,000	41,700
Switzerland	114	30	224	116	43	8	1,340	687	123,000	4,520,000
Taiwan	260	110	265,000	180,000	105	17	2,140	1,130	18	92
Thailand	3,540	1,250	5,170	3,110	17	3	5,930	3,160	25	105
Trinidad and Tobago	245	165	--	--	--	--	32	22	--	--
Turkey	33	9	--	--	--	--	--	--	--	--
United Arab Emirates	1,060	455	665	407	--	--	317	158	2	50
United Kingdom	1,060	233	104,000	61,700	105	20	3,160	1,720	88,000	152,000
Uruguay	45	14	--	--	--	--	21	11	--	--
Venezuela	--	--	--	--	120	56	308	154	--	--
Vietnam	87	41	--	--	--	--	215	108	6	32
Other	208	67	60	32	52	11	575	310	19	123
Total	87,300	49,800	1,280,000	874,000	53,500	4,540	617,000	353,000	3,760,000	5,990,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Containing 99.5% or more by weight of silver.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF SILVER, BY COUNTRY[1]

Year and country	Silver ores and concentrates		Ash and residues		Bullion		Dore		Total	
	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)	Silver content (kilograms)	Value (thousands)
2009	87	$9	505	$151	2,800,000	$1,310,000	653,000	$439,000	3,450,000	$1,750,000
2010:										
Argentina	--	--	--	--	--	--	42,000	54,700	42,000	54,700
Australia	--	--	--	--	43,500	26,100	--	--	43,500	26,100
Belgium	--	--	--	--	972	575	--	--	972	575
Bolivia	--	--	--	--	--	--	115,000	73,300	115,000	73,300
Canada	3,230	1,750	--	--	1,580,000	998,000	595	343	1,590,000	1,000,000
Chile	--	--	--	--	80,000	50,500	155	283	80,200	50,800
Colombia	--	--	--	--	5,990	3,540	1,000	660	6,990	4,200
Costa Rica	--	--	--	--	--	--	90	71	90	71
Czech Republic	--	--	--	--	45	44	--	--	45	44
Dominican Republic	--	--	--	--	--	--	14	15	14	15
Germany	--	--	--	--	1,740	924	246	113	1,990	1,040
Hong Kong	--	--	--	--	87	46	--	--	87	46
India	--	--	--	--	80	38	--	--	80	38
Italy	--	--	--	--	--	--	1,620	911	1,620	911
Japan	--	--	10	7	35,900	31,100	--	--	35,900	31,200
Lebanon	--	--	--	--	25	23	--	--	25	23
Malaysia	--	--	306	67	--	--	--	--	306	67
Mexico	--	--	--	--	2,040,000	1,310,000	534,000	529,000	2,580,000	1,840,000
New Zealand	--	--	--	--	(2)	2	--	--	(2)	2
Panama	--	--	--	--	--	--	725	428	725	428
Peru	--	--	--	--	38,200	27,000	41,900	48,600	80,100	75,600
Poland	--	--	--	--	311,000	191,000	--	--	311,000	191,000
Switzerland	--	--	--	--	30,200	18,300	--	--	30,200	18,300
Taiwan	--	--	(2)	3	--	--	--	--	(2)	3
United Kingdom	--	--	--	--	454,000	231,000	--	--	454,000	231,000
Venezuela	--	--	--	--	233	30	--	--	233	30
Total	3,230	1,750	316	77	4,630,000	2,890,000	738,000	708,000	5,370,000	3,600,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF SILVER, BY COUNTRY[1]

Year and country	Other unwrought silver		Metal powder		Silver nitrate		Semimanufactured forms[2]		Waste and scrap	
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
2009	135,000	$56,100	247,000	$36,400	835	$241	476,000	$176,000	4,760,000	$372,000
2010:										
Argentina	--	--	--	--	--	--	--	--	25,200	512
Australia	--	--	105	5	--	--	1,150	1,100	33,100	2,920
Bahamas	--	--	--	--	--	--	--	--	37,500	8,000
Belgium	--	--	--	--	--	--	6	4	43,700	1,750
Bolivia	--	--	--	--	--	--	--	--	1,010	567
Brazil	--	--	--	--	--	--	4,430	2,010	217,000	2,860
Burkina Faso	--	--	40	4	--	--	--	--	--	--
Canada	107,000	8,750	30,900	1,370	61	6	380,000	213,000	1,560,000	151,000
Cayman Islands	--	--	--	--	--	--	--	--	9,160	13
Chile	--	--	--	--	--	--	--	--	9,140	332
China	105	19	28,200	1,510	--	--	--	--	546,000	9,850
Colombia	--	--	--	--	--	--	1,310	821	22,900	1,950
Costa Rica	36	21	--	--	--	--	--	--	82,900	1,760
Czech Republic	--	--	--	--	--	--	--	--	1,380	95
Dominican Republic	595	753	417	83	--	--	--	--	6,900	6,510
El Salvador	7	3	--	--	--	--	--	--	679	64
France	--	--	12,700	1,030	531	122	(3)	2	685	72
Germany	246	153	12,300	2,940	220	21	13,300	5,600	2,120,000	163,000
Guatemala	--	--	--	--	--	--	--	--	4,050	869
Honduras	--	--	--	--	--	--	3,440	873	401	7,470
Hong Kong	--	--	--	--	--	--	--	--	20,300	725
Hungary	--	--	100	7	--	--	--	--	--	--
India	37	26	--	--	--	--	--	--	17,800	2,950
Indonesia	106	32	--	--	--	--	--	--	4,840	158
Israel	--	--	--	--	--	--	--	--	17,300	361
Italy	138	185	--	--	--	--	57	35	2,210	1,500
Jamaica	14	10	--	--	--	--	54	27	597	5,160
Japan	1	5	655,000	155,000	--	--	6	3	5,960	2,650
Korea, Republic of	--	--	11	13	--	--	--	--	3,810	269
Malaysia	--	--	4,260	209	--	--	--	--	67,000	6,850
Mexico	208,000	132,000	28,100	816	--	--	178,000	103,000	1,120,000	30,900
Netherlands	--	--	153	15	--	--	281	99	246	46
Nicaragua	--	--	--	--	--	--	--	--	1,450	21
Panama	--	--	--	--	--	--	--	--	822	692
Peru	--	--	--	--	6	2	19	15	3,920	$58
Philippines	--	--	--	--	--	--	--	--	720	158
Singapore	--	--	--	--	--	--	1,040	214	89,500	5,480
South Africa	--	--	194	33	--	--	--	--	--	--

See footnotes at end of table.

TABLE 7—Continued
U.S. IMPORTS FOR CONSUMPTION OF SILVER, BY COUNTRY[1]

Year and country	Other unwrought silver		Metal powder		Silver nitrate		Semimanufactured forms[2]		Waste and scrap	
	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)	Gross weight (kilograms)	Value (thousands)
2010—Continued:										
Spain	9	$10	--	--	--	--	1,250	$331	--	--
Sweden	--	--	--	--	--	--	--	--	29,200	$97
Switzerland	--	--	11,900	$6,290	5	$2	47	41	--	--
Taiwan	--	--	300	8	--	--	460	39	4,960	9,160
Thailand	--	--	129	22	--	--	--	--	--	--
Turks and Caicos Islands	--	--	--	--	--	--	--	--	2,830	71
United Arab Emirates	--	--	--	--	--	--	--	--	245	60
United Kingdom	101	19	3,130	444	610	237	53,200	26,700	396,000	6,930
Venezuela	--	--	--	--	--	--	--	--	2,200	8
Other	(3)	3	--	--	--	--	--	--	121	781
Total	316,000	142,000	788,000	170,000	1,430	390	638,000	354,000	6,510,000	435,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Containing 99.5% or more by weight of silver.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8

SILVER: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Algeria	(3)	(3)	(3)	(3)	(3)
Argentina	245	256	356	415 [r]	420 [e]
Armenia	40 [r]	37 [r]	40 [r]	53 [r]	68
Australia	1,727	1,879	1,926	1,635	1,864
Bolivia	472	525	1,114	1,326 [r]	1,259
Brazil[4]	30	36	36 [r]	35 [r]	35 [p]
Bulgaria[e]	65	55	55	55	55
Burma	1	(3)	--	(3)	--
Canada	995	860	728	631 [r]	596 [p]
Chile	1,607	1,936 [r]	1,405	1,301	1,276
China[e]	2,600	2,700	2,800	2,900	3,500
Colombia	8	10	9	11 [r]	15
Congo (Kinshasa)	68	76	34	--	7 [e]
Ecuador	(3)	(3)	(3)	(3) [e]	(3) [e]
Ethiopia	1	1	3 [r]	1 [r]	2 [e]
Finland[e]	50	50	70 [5]	70	70
France[e]	1	1	1	1	--
Ghana	3	3	3	4 [r]	4 [e]
Greece	25	26	28	30 [e]	30 [e]
Guatemala	50	88	100	128	130 [e]
Honduras	55	54 [r]	60 [r]	49 [r]	48 [e]
India	31	82	96	95	92
Indonesia	261	269	226	215	200
Iran[e]	25	20 [r]	15 [r]	15 [r]	20
Ireland[e]	4 [5]	4	4	4	4
Italy[e, 6]	(3)	(3)	(3)	(3)	(3)
Japan	11	5	2	2	1
Kazakhstan	806	723	646	618 [r]	551
Korea, North[e]	20	20	20	20	20
Korea, Republic of	2	1	1	-- [r]	2 [e]
Malaysia	(3)	(3)	(3)	(3)	(3) [e]
Mexico	2,970	3,135	3,236	3,554	4,411
Mongolia	20	20 [r]	20 [r]	20 [r]	20 [e]
Morocco[e]	195 [5]	195	190	195	195
Namibia[e]	31 [5]	30	30	30	30
New Zealand	27	11	18	14	15
Nicaragua	3	3 [r]	4 [r]	4 [r]	5
Oman	(3)	(3)	(3)	(3)	(3)
Papua New Guinea	51	49 [r]	48 [r]	55 [r]	50 [e]
Peru	3,471	3,494	3,686	3,854	3,640
Philippines	24	28	14	34 [r]	41
Poland	1,266	1,199	1,161	1,207 [r]	1,181
Portugal	20	24	29 [r]	22 [r]	23 [p]
Romania[e]	18	18	18	18	18
Russia	974 [r]	911 [r]	1,132 [r]	1,313 [r]	1,145
Saudi Arabia	9 [e]	9	8	10 [e]	9 [e]
Serbia[e]	2	4 [5]	4	4	4
South Africa	87	70	75	78 [r]	79
Spain	2	3	3	4	4 [e]
Sudan[e]	2 [5]	2 [5]	-- [r]	(3) [r]	1 [e]
Sweden	268	270	265	265 [e]	270 [e]
Tajikistan[e]	3 [r]	3 [r]	3 [r]	3 [r]	3

See footnotes at end of table.

TABLE 8—Continued
SILVER: WORLD MINE PRODUCTION, BY COUNTRY[1,2]

(Metric tons)

Country	2006	2007	2008	2009	2010
Tanzania	15	12	10	8 [r]	9 [e]
Turkey	167	198	294 [r]	352 [r]	350 [e]
United States	1,160	1,280	1,250	1,250	1,280
Uzbekistan	62 [r]	78 [r]	75 [r]	53 [r]	59
Zimbabwe[e]	1 [5]	1 [r]	(3) [r]	(3) [r]	1
Total	20,100 [r]	20,800 [r]	21,400 [r]	22,000 [r]	23,100

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data have been rounded to no more than three significant digits; may not add to totals shown.

[2] Recoverable content of ores and concentrates produced unless otherwise specified. Table includes data available through August 19, 2011.

[3] Less than ½ unit.

[4] Includes the following quantities, in kilograms, identified as secondary silver: 2006—39,000; 2007—32,000; 2008—32,500 (revised); 2009—32,500 (revised); and 2010—32,500 (estimated).

[5] Reported figure.

[6] Includes production from imported ores.

SLAG—IRON AND STEEL

By Hendrik G. van Oss

Sales of iron and steel slag in the United States in 2010 totaled about 15.7 million metric tons (Mt), up by about 26% from total sales in 2009 (table 1). The value of slag sales increased by 13% to $266 million overall.

Iron and steel slags are formed by the addition of slagging agents and fluxes (chiefly limestone or dolomite and silica sand) to blast furnaces and steel furnaces to strip impurities from iron ore, steel scrap, and other ferrous feeds. The slag is a silicate melt that floats on top of the molten crude iron or steel and is tapped from the furnace separately from the liquid metal. After being cooled by various means to solid form, the slag is processed and may then be sold and (or) returned to the furnace. Most forms of processed slag have much lower unit values than do iron and steel (metal) and, for this reason, iron and steel companies generally contract with outside slag-processing companies to cool the slag and to remove it. Although the financial arrangements vary, typically the processing company receives the slag for free, crushes it to various marketable sizes, uses screens and magnetic separators to recover entrained metal from the slag (metal to be returned to the furnace for a low charge), sells the slag on the open market, and pays a small percentage of the net slag sales revenues or profits to the iron or steel company. Slag can be returned to the furnaces for use as flux and as a supplemental source of iron, but despite having a value, this return flow is not always included in the tonnages of slag reported as sold.

A listing of slag processors, processing sites, and the iron and steel companies serviced is provided in table 4. Apparent duplication at some sites is because processing contracts may have been transferred to other companies during the year, and it is common for integrated iron and steel plants to have processing and (or) marketing contracts with different companies for different slag types produced at the plant. In some cases, the slag is cooled by one company but is then further processed and (or) marketed by another company or at another site.

Legislation and Government Programs

Consumption of slag for construction is influenced by Federal and State programs that affect construction spending levels, encourage the use of "alternative" materials, and that may affect the availability of competing "alternative" or natural materials. Slags are considered to be "sustainable" raw materials mainly because they can substitute directly or indirectly for virgin raw materials (for example, for natural stone aggregates in concrete and for natural raw materials in cement manufacture), or, in the specific case of ground granulated blast furnace slag (GGBFS), can partially substitute for clinker in finished cement or for portland cement in concrete. With respect to clinker manufacture, substitution of slags for natural raw materials can reduce the unit consumption of fuel and limestone in the kiln, which then reduces the overall and unit emissions of certain pollutants, most notably carbon dioxide. Use of granulated blast furnace slag [GGBFS, or unground (GBFS)] in the finish mill allows more finished cement to be made from the same amount of clinker.

In September 2010, following the release of a proposed ruling in May 2009, the U.S. Environmental Protection Agency (EPA) issued a final rule, within the National Emissions Standards for Hazardous Air Pollutants (NESHAP), for the U.S. cement industry (U.S. Environmental Protection Agency, 2009; 2010). The NESHAP sets very low limits for cement plant emissions of mercury, total hydrocarbons, hydrochloric acid, and particulates, and has the potential, through the closure of plants unable to meet the new limits, to reduce the supply of domestically produced cement on the U.S. market. Although imports of cement would probably make up for some of the reductions in domestic cement supply, the NESHAP has the potential to increase demand for alternative or supplementary cementitious materials (SCM) such as GGBFS and fly ash. Also, the NESHAP likely would make fly ash (typically relatively high in mercury) unattractive as an alternative raw material for clinker manufacture and thus might increase demand for slag for this purpose. The EPA continued to evaluate the reclassification of coal combustion byproducts, including fly ash, as hazardous waste for landfill disposal purposes (but not for beneficial use purposes). Were even a limited designation as hazardous waste to stigmatize fly ash, construction market demand for this material might fall significantly. It remained unclear if the supply of GGBFS and other SCM would be adequate to fill the fly ash void, and this availability issue might work against efforts to promote increased use of these materials.

Production

Data on annual production of slag are generally unavailable because the amount of slag tapped is not routinely measured; also, not all of the slag formed is tapped during a heat. However, U.S. and world production of ferrous slags can be broadly estimated based on typical slag to metal production ratios, which in turn are related to the chemistry of the ferrous feeds to the furnaces. For typical iron ore grades (60% to 66% iron), a blast furnace normally will produce about 0.25 to 0.30 metric tons (t) of slag per metric ton of crude or pig iron produced. For ores of lower than average grade, the slag output will be higher, in some cases as much as 1.0 to 1.2 t of slag per ton of crude iron. Steel furnaces typically produce about 0.2 t of slag per ton of crude steel, but up to 50% of this slag is entrained metal, most of which would be expected to be recovered during slag processing and to be returned to the furnace. The amount of marketable steel slag remaining after entrained metal removal is thus usually equivalent to about 10% to 15% of the crude steel output. Using these ratios and data for U.S. and world iron and steel production from the American Iron and Steel Institute (2010, p. 121–126), U.S. blast furnace slag production in 2010 was estimated to be in the range of about 7 to 8 Mt, and world output, 260 to 310 Mt. Similarly, U.S. output of steel slag (after metal removal) in 2010 was estimated to be 8 to 12 Mt, and world output, 140 to 210 Mt. Apparent production of slag commonly will differ from the sales of slag (table 1) because of a combination of undocumented returns of slag to the furnaces, stockpiling of slag by the processors, and sales from stockpiles; the latter include old slag banks from iron and steel plants long-since closed.

The uses for ferrous slag are determined mainly by how the slag is cooled. Marketed blast furnace slags are of three main types—air-cooled, granulated, and pelletized (or expanded). Air-cooled blast furnace slag is formed by allowing the molten slag to cool relatively slowly under ambient conditions; final cooling can be accelerated with a water spray. Although it can have a vesicular texture with closed pores, the air-cooled slag is hard and dense and is especially suitable for use as construction aggregates. Formation of GBFS is by quenching molten slag in water to form sand-sized particles of glass. The disordered structure of this glass gives the material inherent moderate hydraulic cementitious properties when the slag is very finely ground (GGBFS), and the cementitious properties become strong if the material accesses free lime during hydration. In concrete containing a proportion of GGBFS, hydration of portland cement releases the lime needed to fully activate the slag. Concretes incorporating GGBFS generally develop strength more slowly than concretes that contain only portland cement but can have similar or even superior long-term strength, release less heat during hydration, have reduced permeability, and generally exhibit improved resistance to chemical attack. Pelletized or expanded slag is cooled through a water jet, which leads to rapid steam generation and the development of innumerable vesicles within the slag. The vesicles reduce the overall density of the slag and allows for good mechanical binding with hydraulic cement paste. This slag type is most commonly used as a lightweight aggregate, but if very finely ground, it can have cementitious properties similar to those of GGBFS. Blast furnace slag (generally air-cooled) also can be made into mineral wool. For this purpose, slag is remelted and then poured through an air stream or jet of steam or other gas to produce a spray of molten droplets; alternatively, the droplets can be formed by passing the melt through a perforated or fast spinning disc. The droplets elongate into long fibers that are collected and layered, and this material is suitable for use as thermal insulation.

Steel furnace slag is cooled similarly to air-cooled blast furnace slag, has similar properties to it, and is used for some of the same purposes. Steel slags containing large amounts of dicalcium silicate are prone to expansion and commonly are cured in piles for several months to allow for the expansion and for leaching out of lime.

Consumption

Data in this report are from an annual U.S. Geological Survey (USGS) canvass of slag processors and importers and pertain to sales of processed slag, not the amount of slag produced or processed during the year. Processed slag is sold from stockpiles and although most of the material is a byproduct of current or recent iron and steel output or is of imported material, some slag sales are of material mined from old slag piles (slag banks) produced by iron and steel plants now closed. In 2010, canvasses were sent to 24 companies, covering 138 processing and (or) importation sites, and at least partial data (some as consolidated responses) were received for 132 sites; the reported data accounted for slightly more than 98% of the total iron and steel slag tonnage in table 1. In 2009, canvasses were sent to 22 companies, covering 137 sites, and at least partial data were received for 130 sites, accounting for slightly more than 96% of the gross tonnage listed for the year. Because of the wide range in the level detail in the data reported to the USGS, and the need to estimate activities of survey nonrespondents, the data in table 1 have been heavily rounded. For both years, data on pelletized blast furnace slag have been withheld to avoid disclosing company proprietary data, but the quantities sold were very small. Sales data for granulated slag in both years exclude material sold by importers who as yet do not take part in the USGS canvass.

Sales data for slag exclude much of the ferrous slag returned to the furnaces, although more respondents provided data on this flow in 2010 than in previous years. The sales data also exclude the free metal recovered from the slag. Total slag sales increased by almost 26% in 2010 (table 1), owing significantly to improved slag availability resulting from a return to service of a number of previously idle iron and steel furnaces during the year. This appears to have been especially true for steel slag, but the 44% increase in sales tonnage noted in table 1 partially reflects the increased reporting, as sales, of slag returns to the furnaces. As in 2009, more than 80% of slag sales in 2010 were of air-cooled blast furnace slag and of steel slag. Both of these slag types are used as aggregates in general construction. However, because their market areas tend to be somewhat restricted geographically relative to natural construction materials, and because sales commonly are based upon long-term contracts, trends in slag consumption commonly differ, at least in terms of relative percentage changes, from sales trends for competing materials, and for cement. For example, total crushed stone sales in 2010 were unchanged from those in 2009, sand and gravel sales were down by 6%, and cement sales (which are a useful proxy for concrete sales) declined slightly (0.4%).

As noted above, air-cooled blast furnace and steel furnace slags are used primarily for a variety of aggregate applications (table 3). Because of potential expansion problems, steel slag finds little use in applications requiring maintenance of a fixed volume (for example, concrete). Both slag types also are used as a raw material for cement (clinker) manufacture (the slag contributes several major oxides), but steel slag has proven to be especially suitable for this use. Differences evident in table 3 among the usage breakout percentages for these two slag types continue to be difficult to evaluate because the data incorporate estimates and much of the plant-level data reported in recent years have revealed only the dominant use(s) for the slag and thus the less common uses are likely understated. For example, although the percentage decline in the use of air-cooled slag for ready-mixed concrete is in some agreement with the apparent decline in concrete sales in 2010, the magnitude of the decline for slag is questionable given the large increase in the proportion of sales reported for miscellaneous or unspecified uses. Steel slag sales in 2010 appear to show significant declines in use for road construction and paving, but an increase in use for fill purposes. For the other usage categories in table 3, the differences for the 2 years shown do not appear to be significant.

Notwithstanding higher sales volumes, unit prices for air-cooled and steel slags were substantially unchanged in 2010 (tables 1, 2); the base data contain estimates and few breakout details and thus small changes are likely to be of no statistical significance. Because of generally low unit sales values, slag sold for aggregate generally cannot be economically transported over long distances, particularly overland. Thus, the major factors affecting the sales volumes and prices of these two slag types are dominated by local competition from natural aggregates, the overall level of construction activity (particularly that for roads), and the existence of long-term supply contracts. Air-cooled and steel furnace slags sold for uses other than aggregates can command higher prices than slags sold as aggregates. Pelletized slag (not revealed in tables 1–3) can sell for prices well above those for air-cooled slag.

Sales of GBFS in 2010 increased by 18% to 2.6 Mt. Although this represented just 17% of total slag sales, GBFS has a comparatively high unit value (table 2) and accounted for 70% of total slag sales value and 84% of total blast furnace slag sales value (table 1). Actual sales of GBFS in some years have been higher than those shown in table 1 because of some imports being missed by the USGS canvass; however, it is unclear if this was the case in 2009–10. About 92% of total reported GBFS sales in 2009–10 were of GGBFS and the rest was unground material. The high unit sales value of GBFS reflects the dominant use of GGBFS as a partial substitute for portland cement in blended cements and in concrete. Despite its relatively high unit price, GGBFS has in most years sold at a 20% to 25% discount to portland cement. The discount was about 17% in 2010, however, owing to a significant decline in the price of portland cement. Overall sales of GBFS and GGBFS for cementitious uses totaled 2.5 Mt in 2010, up by 19%. A small fraction of the unground GBFS on the market has been sourced from old slag piles and lacks cementitious character as a result of weathering; this material still has use as a fine grained aggregate in concrete, but sells for much lower prices than those indicated for the cementitious material in table 2.

The USGS slag survey does not distinguish between GBFS sold directly to cement companies and that sold directly to concrete companies, but data from recent USGS cement surveys indicate that cement producers consume only about 15% of the total granulated slag sold, including that used to make blended cement and that used as a grinding aid to make portland cement. Sales in the United States of GGBFS under the designation "slag cement" are promoted by the Slag Cement Association (SCA), whose members account for much of the country's GGBFS output. The SCA reported sales by its members of 2.0 Mt of GGBFS in 2010, a decline of 2.5% (Slag Cement Association, unpub. data, September 2011).

Foreign Trade

Actual ferrous slag imports are almost entirely of GBFS or GGBFS, but the data within the appropriate tariff code commonly contain entries that, because of unreasonably high or low unit dollar values, are likely either slags of other metallurgical industries or are unrelated materials entirely (such as silica fume, cenospheres from fly ash, other industrial residues, or metal concentrates). For example, data from the U.S. Census Bureau list imports of granulated slag totaling about 1.38 Mt in 2010, up by about 7% from levels in 2009, but the 2010 total includes 0.03 Mt of imports from Italy at a listed average cost-insurance-freight (c.i.f) valuation of $251.85 per metric ton and 0.24 Mt of material from South Africa at $354.36 per ton—these values, if accurate, appear to be too high to be GGBFS. Accordingly, the true tonnage of granulated slag imports is unclear. Taken as listed by the Census Bureau, the leading import sources of GBFS tonnages in 2010 were Japan (41%), Canada (29%), South Africa (18%), and France (6%). Comparison of the Census Bureau import data for slag with data from the United Business Media Ltd.'s Port Import Export Reporting Service (PIERS) has generally revealed higher totals for PIERS in recent years, suggesting that the Census Bureau data were incomplete. In 2010, the PIERS total was 1.46 Mt.

Outlook

Future slag demand will reflect trends in overall construction spending, especially for public sector projects; it is expected that it will take some years for slag sales to return to the levels of about 20 Mt per year experienced during the boom construction years of 2004 through 2006. Slag sales are expected to benefit from Government programs to promote the use of recovered mineral components in public sector construction projects but may not be able to capture a large share of this market because of limited slag availability. The declining number of operating blast furnaces in the United States makes the future supply of air-cooled blast furnace slag highly vulnerable to even temporary closure of integrated iron and steel complexes, such as were experienced in 2009. Steel slag supplied from basic oxygen furnaces is also vulnerable to closures, but slag availability from electric arc furnaces is more assured. An increasing constraint on steel slag availability for construction projects is a recent tendency for steel plants to retain more slag for return to the furnaces at times of high prices for iron ore and scrap. In terms of actual sales volumes, however, the effects of these increased returns to the furnace are hard to quantify because of the tendency of slag processors to stockpile slag so as to be able to bid on large projects. Slags are useful alternative raw materials for clinker production, and such use can reduce a cement plant's fuel consumption and overall emissions of carbon dioxide. Availability of sufficient slag near cement plants will continue to be a major determinant of demand for this purpose, as will the slag's chemical suitability.

The cement and concrete industries have increasingly accepted GGBFS as a cementitious component and this should ensure a steady or growing market share for this slag type. The supply of GBFS from domestic blast furnaces, however, will remain severely constrained by the fact that granulation cooling is currently installed at only four blast furnaces in the United States. Installation of granulators at other blast furnaces is possible but unlikely; it is expensive and would depend upon the perception of the specific furnace's future viability, and not all blast furnaces produce a slag that is chemically suitable for GGBFS. Thus, increases in GGBFS sales will likely depend on the availability of imported GGBFS or GGBFS ground from imported granules.

Current proposed changes in environmental rules governing the manufacture of portland cement and the characterization of fly ash have the potential of increasing the demand for slag as an alternative raw material for clinker manufacture and as an SCM.

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GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publication

Iron and Steel Slag. Ch. in Mineral Commodity Summaries, annual.

Other

National Slag Association.
Portland Cement Association.
Slag Cement Association.

TABLE 1
IRON AND STEEL SLAG SOLD OR USED IN THE UNITED STATES

(Million metric tons and million dollars)

	2009					2010				
	Blast furnace slag[1]			Steel furnace slag	Total iron and steel slag[2]	Blast furnace slag[1]			Steel furnace slag	Total iron and steel slag[2]
	Air-cooled	Granulated	Total			Air-cooled	Granulated	Total		
Quantity	4.6	2.2	6.8	5.7	12.5	4.9	2.6	7.5	8.2	15.7
Value[e]	33	172	205	30	235	37	186	222	44	266

[e] Estimated.

[1] Excludes expanded (pelletized) slag to protect company proprietary data. The quantities are very small (about 0.1 unit or less).

[2] Data may not add to totals shown because of independent rounding.

TABLE 2

SELLING PRICES FOR IRON AND STEEL SLAG IN THE UNITED STATES[1]

(Dollars per metric ton)

	2009		2010	
Slag type	Range	Average	Range	Average
Blast furnace slag:				
Air-cooled	3.31 – 19.84	7.35	3.34 – 18.40	7.48
Granulated[2]	20.00 – 100.00	81.37	16.53 – 102.69	74.51
Steel furnace slag	0.19 – 14.66	5.28	0.02 – 24.25	5.37

[1] Data contain a large component of estimates, and some respondents provide values only on their total sales of a slag type, not value by type of use. Thus, the value ranges shown are likely too restrictive.

[2] Values are for material reported for use as a cementitious additive in cement or concrete manufacture. Material at or near the low end of the range was sold in unground form. Sales other than for cementitious use were generally at unit values below the ranges shown.

TABLE 3

SALES OF FERROUS SLAGS IN THE UNITED STATES, BY USE[1]

(Percentage of total tons sold)

	2009			2010		
	Blast furnace slag[2]		Steel slag	Blast furnace slag[2]		Steel slag
Use	Air-cooled	Granulated		Air-cooled	Granulated	
Ready-mixed concrete	16.4 ^{r}	--	--	13.4	--	--
Concrete products	4.0 ^{r}	--	--	4.3	--	--
Asphaltic concrete	16.3 ^{r}	--	8.1 ^{r}	17.6	--	3.1
Road bases and surfaces	39.6 ^{r}	4.1 ^{r}	59.3 ^{r}	37.6	4.4	42.8
Fill	9.1 ^{r}	--	12.6 ^{r}	4.7	--	32.5
Cementitious material	--	94.6 ^{r}	--	--	95.1	--
Clinker raw material	1.1 ^{r}	0.9 ^{r}	2.3 ^{r}	0.4	(3)	2.5
Miscellaneous[4]	12.1 ^{r}	0.4 ^{r}	0.5	12.0	0.5	0.3
Other or unspecified[5]	1.4	--	17.2 ^{r}	10.0	--	18.8

^{r}Revised. -- Zero.

[1] A number of respondents provide breakouts that represent only the dominant use(s) of their slag; accordingly, the minor use categories are likely underreported. The data also incorporate some estimates and thus should be viewed as accurate to no more than two significant figures.

[2] Excludes expanded or pelletized slag; this material is generally sold as a lightweight aggregate.

[3] Less than 0.1%.

[4] Reported as used for railroad ballast, roofing, mineral wool, or soil conditioner.

[5] Including return to furnaces (likely underreported) and other uses.

TABLE 4

PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2010

			Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
Slag processing company	Plant location	Steel company serviced[2, 3]	AC	GG	Exp	BOF	OHF	EAF
Alexander Mill Services Inc.	Hollsopple, PA	North American Höganäs, Inc.						X
Ash Grove Cement Co.	Portland, OR	Foreign		X				
Barfield Enterprises, Inc.	LaPlace, LA	ArcelorMittal USA						X
Beaver Valley Slag	Aliquippa, PA	Old slag pile site	X			X	X	
Beelman Truck Co.	Granite City, IL[4]	United States Steel Corp.	X					
Beemsterboer Slag Corp.	East Chicago, IN	ArcelorMittal USA ("East side")	X					
Do.	Gary, IN	United States Steel Corp.	X					
Blackheart Slag Co.	Muscatine (Montpelier), IA	SSAB North America						X
City Slag LLC	Sharon, PA	Old slag pile site					X	
Dragon Products Co., Inc.	Thomaston, ME	Miscellaneous domestic and foreign		X				
Edward C. Levy Co.	Decatur (Trinity), AL	Nucor Corp.						X
Do.	Butler, IN	Steel Dynamics, Inc.						X
Do.	Columbia City, IN	do.						X
Do.	Crawfordsville, IN	Nucor Corp.						X
Do.	East Chicago (Indiana Harbor), IN	ArcelorMittal USA ("West side")	X					
Do.	Detroit (Dearborn), MI	Severstal North America, Inc.	X			X		
Do.	Detroit (Ecorse), MI	United States Steel Corp.	X			X		
Do.	Columbus, MS	Severstal North America, Inc.						X
Do.	Canton, OH	The Timken Co.						X
Do.	Delta, OH	North Star BlueScope Steel LLC						X
Do.	Huger, SC	Nucor Corp.						X
Do.	Memphis, TN	do.						X
Do.	Seattle, WA	do.						X
Essroc Corp.	Middlebranch, OH	Miscellaneous domestic and foreign		X				
Fritz Enterprises, Inc.	Fairfield, AL[5]	United States Steel Corp.	X	X		X		
Do.	Sparrows Point, MD	Severstal North America, Inc.	X					
Gerdau Ameristeel Corp.	Jacksonville, FL	Gerdau Ameristeel Corp.						X
Do.	Charlotte, NC	do.						X
Harsco Metals Corp.	Birmingham, AL	SMI/CMI Steel Group						X
Do.	Blytheville, AR	Nucor Corp.						X
Do.	Blytheville (Armorel), AR	Nucor-Yamato Steel Co.						X
Do.	Pueblo, CO	Evraz Inc. NA						X
Do.	Wilton (Muscatine), IA	SSAB North America						X
Do.	Pittsboro, IN	Steel Dynamics, Inc.						X
Do.	Ghent, KY	Gallatin Steel Co.						X
Do.	do.	North American Stainless						X
Do.	Ahoskie (Cofield), NC	Nucor Corp.						X
Do.	Mansfield, OH[6]	AK Steel Corp.				X		
Do.	Warren, OH	Severstal North America, Inc.				X		
Do.	Brackenridge, PA	Allegheny Ludlum Corp.						X

See footnotes at end of table.

TABLE 4—Continued

PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2010

Slag processing company	Plant location	Steel company serviced[2, 3]	Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
			AC	GG	Exp	BOF	OHF	EAF
Harsco Metals Corp.—Continued:	Butler, PA	AK Steel Corp.						X
Do.	Coatesville, PA[6]	ArcelorMittal USA						X
Do.	Koppel, PA	TMK IPSCO						X
Do.	Latrobe, PA	Allegheny Ludlum Corp.						X
Do.	Midland, PA[7]	do.						X
Do.	Natrona Heights, PA[8]	do.						X
Do.	Steelton, PA	ArcelorMittal USA						X
Do.	Midlothian, TX	Gerdau Ameristeel Corp.						X
Do.	Geneva (Provo), UT	Old slag pile site	X			X		
Holcim (US) Inc.	Birmingham (Fairfield), AL[5]	United States Steel Corp.		X				
Do.	Camden, NJ	Foreign		X				
Do.	Gary, IN	United States Steel Corp.		X				
Lafarge North America Inc.	South Chicago, IL	ArcelorMittal USA		X				
Do.	East Chicago (Indiana Harbor), IN[9]	do.		X	X			
Do.	Sparrows Point, MD	Severstal North America, Inc.	X	X				
Do.	Cleveland (Cuyahoga Co.), OH[4]	ArcelorMittal USA	X					
Do.	Lordstown, OH	Old slag pile site		X				
Do.	McDonald, OH	do.	X					
Do.	Salt Springs (Youngstown), OH	do.	X					
Do.	Warren, OH[10]	Severstal North America, Inc.	X					
Do.	West Mifflin (Duquesne), PA	United States Steel Corp. (ET Works)	X					
Do.	Seattle, WA	Foreign		X				
Lehigh Hanson, Inc.	Cementon, NY	do.		X				
Do.	Evansville, PA	do.		X				
Do.	San Francisco, CA	do.		X				
Lehigh/Hanson Slag Cement, Inc.	Cape Canaveral, FL	do.		X				
The Levy Co., Inc.	Burns Harbor, IN	ArcelorMittal USA	X			X		
Mountain Materials, Inc.	Ashland, KY[4]	AK Steel Corp.	X					
Phoenix Services LLC	Riverdale, IL	ArcelorMittal USA				X		
Do.	Indiana Harbor, East Chicago, IN[11]	do.				X		
Do.	Wilton, IA	Gerdau Ameristeel Corp.						X
Do.	Sparrows Point, MD	Severstal North America, Inc.				X		
Do.	Cool Springs/Steubenville, OH	Old slag pile site				X		
Do.	Warren, OH[10]	Severstal North America, Inc.	X					

See footnotes at end of table.

TABLE 4—Continued
PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2010

Slag processing company	Plant location	Steel company serviced[2, 3]	Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
			AC	GG	Exp	BOF	OHF	EAF
Phoenix Services LLC—Continued:	Johnstown, PA	Old slag pile site	X					
Do.	Latrobe, PA	Latrobe Specialty Steel Co.						X
Do.	Vinton (El Paso), TX	ArcelorMittal USA						X
Do.	Roanoke, VA	Steel Dynamics, Inc.						X
Do.	Weirton, WV	Old slag pile site					X	
Recmix of PA, Inc.	Ghent, KY	North American Stainless						X
Do.	Sarver (Brackenridge), PA	Allegheny Ludlum Corp.						X
Rinker Materials Corp.	Miami, FL	Foreign		X				
St. Marys Cement Inc.	Detroit, MI	do.		X				
Do.	Milwaukee, WI	Domestic and foreign		X				
Stein, Inc.	Alton, IL	Alton Steel Inc.						X
Do.	Granite City, IL[4]	United States Steel Corp.	X			X		
Do.	Sterling, IL	Sterling Steel Co., LLC						X
Do.	Ashland, KY[4]	AK Steel Corp.	X			X		
Do.	Canton, OH	Republic Engineered Products, Inc.						X
Do.	Cleveland, OH[4]	ArcelorMittal USA	X			X		
Do.	Loraine, OH	Republic Engineered Products, Inc.	X			X		
Do.	Mansfield, OH[6]	AK Steel Corp.				X		
Do.	Coatesville, PA[6]	ArcelorMittal USA						X
Do.	Georgetown, SC	Georgetown Steel Corp.						X
Tube City IMS, LLC	Axis, AL	SSAB North America						X
Do.	Birmingham, AL	Nucor Corp.						X
Do.	Tuscaloosa, AL	do.						X
Do.	Fort Smith, AR	GerdauMACSTEEL						X
Do.	Rancho Cucamonga, CA	TAMCO Steel						X
Do.	Claymont, DE	Evraz Inc. NA						X
Do.	Cartersville, GA	Gerdau Ameristeel Corp.						X
Do.	Kankakee, IL	Nucor Corp.						X
Do.	Peoria, IL	Keystone Steel & Wire Co.						X
Do.	Gary, IN	United States Steel Corp.				X		
Do.	Portage, IN	NLMK Indiana (Beta Steel Corp.)						X
Do.	Ashland, KY	Kentucky Electric Steel LLC						X
Do.	Jackson, MI	GerdauMACSTEEL						X
Do.	Monroe, MI	do.						X

See footnotes at end of table.

TABLE 4—Continued

PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2010

Slag processing company	Plant location	Steel company serviced[2, 3]	Slag and furnace types[1]					
			Blast furnace slag			Steel furnace slag		
			AC	GG	Exp	BOF	OHF	EAF
Tube City IMS, LLC—Continued:	St. Paul, MN	Gerdau Ameristeel Corp.						X
Do.	Jackson, MS	Nucor Corp.						X
Do.	Norfolk, NE	do.						X
Do.	Perth Amboy, NJ	Gerdau Ameristeel Corp.						X
Do.	Sayreville, NJ	do.						X
Do.	Auburn, NY	Nucor Corp.						X
Do.	Marion, OH	do.						X
Do.	Middletown, OH	AK Steel Corp.	X			X		
Do.	Mingo Junction, OH	Severstal North America, Inc.	X			X		X
Do.	Youngstown, OH	V&M Star						X
Do.	Sand Springs, OK[12]	Gerdau Ameristeel Corp.						X
Do.	McMinnville, OR	Cascade Steel Rolling Mills, Inc.						X
Do.	Braddock, PA	United States Steel Corp.				X		
Do.	Bridgeville, PA	Universal Stainless & Alloy Products, Inc.						X
Do.	New Castle, PA	Ellwood Quality Steels Co.						X
Do.	Park Hill (Johnstown), PA	Old slag pile site	X				X	
Do.	Pricedale, PA	do.				X		
Do.	Reading, PA	Carpenter Technology Corp.						X
Do.	Cayce, SC	SMI/CMC Steel Group						X
Do.	Darlington, SC	Nucor Corp.						X
Do.	Jackson, TN	Gerdau Ameristeel Corp.						X
Do.	Knoxville, TN	do.						X
Do.	Beaumont, TX	do.						X
Do.	Jewett, TX	Nucor Corp.						X
Do.	Lone Star, TX	Lone Star Steel Co.						X
Do.	Longview, TX	LeTourneau Technologies Steel Products						X
Do.	Seguin, TX	SMI/CMC Steel Group						X
Do.	Plymouth, UT	Nucor Corp.						X
Do.	Petersburg, VA	Gerdau Ameristeel Corp.						X
Do.	Saukville, WI	Charter Steel						X
Uniserve LLC	Newport, AR	Arkansas Steel Associates, LLC						X
Do.	Gallatin, TN	Hoeganaes Corp.						X
Vulcan Materials Co.	Tampa, FL	Foreign		X				

Do., do. Ditto.

[1] Blast furnace slag type abbreviations: AC = air-cooled; GG = granulated; Exp = expanded. Steel furnace slag types: BOF = basic oxygen furnace; OHF = open hearth furnace;

TABLE 4—Continued

PROCESSORS OF IRON AND STEEL SLAG IN THE UNITED STATES IN 2010

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[2] "Foreign" refers to the fact that the facility imports unground granulated blast furnace slag and grinds it onsite to make ground granulated blast furnace slag—commonly now referred to as "slag cement." "Domestic" implies grinding slag sourced from the domestic market, not a service contract.

[3] Currently operating iron and (or) steel company. Company is not shown for old slag pile sites.

[4] For the air-cooled slag, Stein Inc. was responsible for the cooling but the processing and marketing were handled by Beelman Trucking (Granite City, IL), Lafarge Corp. (Cleveland, OH), and Mountain Materials, Inc. (Ashland, KY), respectively.

[5] For granulated slag, Fritz Enterprises, Inc. operates the granulator but Holcim (US) Inc. owns the apparatus and markets the slag.

[6] The contracts for Mansfield, OH, and Coatesville, PA, were transferred to Stein, Inc. in mid-2010.

[7] The contract for Midland, PA, was captured by Harsco Metals Corp. at the end of 2009.

[8] Allegheny Ludlum Corp. closed the meltshop at Natrona Heights, PA, in July 2010.

[9] Lafarge grinds some of the granulated slag from East Chicago, IN, at several of its cement plants located elsewhere.

[10] The contract for Warren, OH, was captured by Phoenix Services LLC in October 2010.

[11] Both "east" and "west" sides.

[12] The Sand Springs, OK, plant closed in June 2010.

SODA ASH

By Dennis S. Kostick

Domestic survey data and tables were prepared by Martha L. Jackson, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

The U.S. soda ash industry began to rebound in 2010 after experiencing a decline in domestic and export sales caused by adverse global economic conditions in 2009 in the major soda ash-consuming sectors. Although the annual average unit value of soda ash fell in 2010, soda ash production and exports increased. The total value of U.S. soda ash production was $1.36 billion (table 1).

Soda ash, also known as sodium carbonate (Na_2CO_3), is an alkali chemical refined from the mineral trona or naturally occurring sodium-carbonate-bearing brines (the soda ash from both is referred to as natural soda ash) or manufactured from one of several chemical processes (the soda ash from this process is referred to as synthetic soda ash).

Soda ash is an important industrial compound used to manufacture chemicals, glass, pulp and paper, soaps and detergents, and many other familiar consumer products. The United States has the world's largest natural deposit of trona and is the world's second ranked soda ash-producing nation. U.S. natural soda ash is extremely competitive in world markets because the majority of the world output of soda ash is made synthetically, which is usually a more expensive process.

Production

Soda ash production and inventory data were collected by the U.S. Geological Survey (USGS) from monthly, quarterly, and annual voluntary surveys of the U.S. soda ash industry. A survey request was sent to each of the five soda ash companies, all of which responded, representing 100% of the total production data in this report (table 1).

The United States remained the world's second ranked soda ash-producing nation in 2010. After more than a century of the United States leading in the world's production of soda ash, China overtook the United States in 2003, and it appeared that China would continue to be the world's leader for the foreseeable future. U.S. production of natural soda ash from California and Wyoming was 10.6 million metric tons (Mt) in 2010. Based on about 14.5 million metric tons per year (Mt/yr) (16 million short tons per year) of total nameplate production capacity, the U.S. soda ash industry operated at 73% of total capacity. This capacity utilization rate appears to be low because it is calculated partially based on the full nameplate capacity of 900,000 metric tons per year (t/yr) (1 million short tons per year) for Solvay Chemicals, Inc.'s Parachute, CO, plant; 816,000 t/yr (900,000 short tons per year) for OCI Chemical Corp.'s plant; and 726,000 t/yr (800,000 short tons per year) for FMC Corp.'s Granger plant, some of which included nameplate capacity idled since 2009.

Approximately 2.45 Mt/yr of nameplate capacity (2.70 million short tons per year), which represented about 17% of total industry nameplate capacity, was idled in 2010. This available capacity could be brought back online when market conditions improve. The U.S. soda ash industry used the term "effective capacity" to minimize the effect that "mothballed capacity" had on operating rates. This resulted in higher capacity utilization percentages. Individual effective capacity data are not publicly disclosed. Producers use nameplate capacities to determine export allocations set by a U.S. export association, the American Natural Soda Ash Corp. (ANSAC).

The U.S. soda ash industry consisted of five companies in 2010—four companies operating five plants in Wyoming that produced soda ash from underground trona ore and one in California that produced soda ash from sodium-carbonate-rich brines. Solvay operated a plant in Wyoming and a plant in Colorado, which was mothballed in September 2004 but continued sodium bicarbonate production using soda ash feedstock from the company's Wyoming soda ash facility.

Each of the U.S. companies is either wholly owned or partially owned by foreign soda ash-producing companies or foreign soda ash consumers. The U.S. soda ash industry was 62% foreign owned and 38% domestically owned. At yearend, the countries and percentage ownership were India, 34%; Belgium, 31%; Japan, 18%; and the Republic of Korea, 17% (table 2).

Consumption

The USGS collects soda ash consumption data by end use on a quarterly basis from the marketing and sales departments of each company. Every effort has been made to categorize company sales within the correct end-use sector. Quarterly reports are often revised in subsequent quarters because of customer reclassifications or other factors. All U.S. soda ash companies responded to the quarterly surveys; data represented 100% of the total reported consumption data found in this report.

In 2010, U.S. apparent consumption and reported consumption were virtually identical. Apparent consumption of soda ash was 5.20 Mt; reported consumption was 5.27 Mt (table 1). Reported consumption and apparent consumption do not necessarily correspond because reported consumption is sales reported by producers, whereas apparent consumption is the calculated quantity available for domestic consumption based on balancing supply (production, imports, and inventory adjustments) with external demand (exports).

When the two types of consumption do not closely correspond, the difference is usually attributed to a discrepancy in the export data that were used to derive consumption statistics. The two sources for export data were the U.S. Census Bureau, which reports exports upon departure from U.S. ports, and the California and Wyoming soda ash producers, which consider shipments to be exported when their export association, ANSAC, takes consignment of the product at the Wyoming plant sites. Transit times between the plant and port, which can be about 2 to 3 weeks before the cargo is actually exported, and carryover export inventories contribute to the discrepancy between reported and apparent consumption as well.

In the domestic market, large-volume buyers of soda ash were primarily the major glass container manufacturers whose purchases were seasonal (more beverage containers are made in the second and third quarters for summertime beverage consumption). Soda ash sales to the flat glass sector depended more on the state of the economy because the leading uses of flat glass were in automobile manufacture and residential housing and commercial building construction. These two major industrial sectors are especially sensitive to changing economic conditions, and soda ash sales follow trends in the two sectors. The distribution of soda ash by end use in 2010 was glass, 48%; chemicals, 29%; soap and detergents, 10%; distributors, 5%; flue gas desulfurization, 4%; other uses and pulp and paper, 2% each; and water treatment, less than 1% (table 3).

Chemicals.—Soda ash is used to manufacture many sodium-base inorganic chemicals, including sodium bicarbonate, sodium chromates, sodium phosphates, and sodium silicates.

Glass.—Glass manufacture represented about 48% of domestic soda ash consumption as follows: container, 51%; flat, 38%; fiber, 6%, and other, 5%. Glass containers are made for beverages (beer, carbonated, and noncarbonated drinks), chemical and household products, food, liquor, medical products, and toiletries and cosmetics.

Soaps and Detergents.—Detergents were the third ranked use of soda ash. Soda ash was used as a builder to emulsify oil stains, to reduce the redeposition of dirt during washing and rinsing, to provide alkalinity for cleaning, and to soften laundry water. In addition, soda ash was a component of sodium tripolyphosphate (STPP), another major builder in detergent formulations. Soda ash consumption has been decreasing because phosphatic detergents can contribute to eutrophication, which is an environmental concern. Many regions of the Nation have adopted phosphate limitations or bans, affecting about 40% of the U.S. population.

In response to the environmental concern that cardboard detergent packaging contributes to the volume of landfill waste, detergent manufacturers changed formulations to make compact and superconcentrated products. These reformulations required sodium silicates and synthetic zeolites, which are made from soda ash. Liquid detergents, which do not contain any soda ash, competed with powdered detergents and commanded about 50% of the household laundry detergent market in 2010.

Stocks

Yearend 2010 stocks of dense soda ash in domestic plant silos, terminals, warehouses, and on teamtracks amounted to 220,000 metric tons (t). Producers indicated that a potential supply problem could exist if inventories fell below 180,000 t. Most consumers of soda ash did not have the storage facilities to accommodate large quantities of soda ash and had to rely on suppliers to provide the material on a timely basis.

Prices

The annual average value in 2010 for bulk, dense natural soda ash, free on board (f.o.b.) Green River, WY, and Searles Valley, CA, was $128.39 per metric ton ($116.47 per short ton), which was a 10% decrease from the record high of $143.17 per ton ($129.88 per short ton) set in 2009. Part of the price decrease was because export prices in 2010 declined. The value is not a "price," but rather the value of the combined revenue of California and Wyoming bulk, dense soda ash sold on an f.o.b. plant basis at list, spot, or discount prices, on long-term contracts, and for export, divided by the quantity of soda ash sold. Only merchant soda ash is used to derive the annual value; therefore, no soda ash for value-added products or soda liquors is included. The list prices quoted in trade journals or by producers differed from the annual average values reported to and by the USGS.

In May, FMC announced a soda ash price increase of $10 per short ton effective July 1, 2010, or as contracts allowed for all grades of soda ash. The company stated the increase was necessary to "recover cost increases and to support continued investment in the business." The new list price for bulk, dense soda ash was $260 per short ton (FMC Corp., 2010a).

In September, FMC again announced another $10 per short ton rise effective November 1, 2010, or as contracts permit, for all grades of soda ash (FMC Corp., 2010b).

General Chemical (Soda Ash) Partners raised its list price of soda ash on September 7, effective immediately or as contract terms permit, by $10 per short ton to $260 per short ton (General Chemical Industrial Products, 2010).

Foreign Trade

The majority of U.S. soda ash exports were controlled by ANSAC, which is involved exclusively in the export trade of soda ash, defined as an alkali product designated by the chemical formula Na_2CO_3, whether manufactured by brine evaporation and purification, Solvay process, trona refining, or any other means. Under the Treaty of Rome agreement (1958), ANSAC is not permitted to ship soda ash to the European Union (EU); however, the members of the U.S. soda ash industry formed another organization for shipping to this region. It is the American-European Soda Ash Shipping Association, Inc. (AESSA) that is engaged solely in storage, transportation, and other related logistical and technical support activities to promote and further its members' individual commerce in soda ash being shipped to the EU. Both ANSAC and AESSA were formed as Webb-Pomerene export associations under the authority of the U.S. Federal Trade Commission.

In August, ANSAC announced it would raise prices of soda ash for export by $30 per metric ton on a worldwide basis effective October 1, 2010. The action was a result of strong demand for soda ash around the world (ANSAC, 2010).

According to the U.S. Census Bureau, U.S. soda ash exports for 2010 were 5.39 Mt, which represented about 51% of U.S. soda ash production. For comparison, exports accounted for only 5% of U.S. production in 1970, 13% in 1980, 26% in 1990, and 38% in 2000. In 2010, the regional percentage distribution of U.S. exports to 56 countries, was South America, 28%; Asia, 27%; North America, 20%; Europe, 11%; Africa, 6%; the Middle East, 4%; Oceania, 2%; Central America, 1%; and the Caribbean, negligible (table 5). The average free alongside ship value was $164.38 per metric ton in 2010 compared with $190.02 per ton in 2009. Although the data in tables 1 and 6 are rounded to three significant digits, the unit values listed in table 6 are based on the unrounded statistics. The 10 leading countries, representing 67% of total U.S. soda ash exports, in decreasing order and percentage of total were Mexico, 17%; Brazil, 13%; Indonesia, 9%; Canada, 5%; Chile, 5%; Taiwan, 5%; Venezuela, 5%; Japan, 4%; Republic of Korea, 4%; and Belgium, 3% (table 6). About 43% of all U.S. soda ash exports went through the Columbia-Snake River customs district in Idaho, Oregon, and Washington, the Port Arthur, TX, customs district was the second-ranked customs district with 31% of the total, and the Laredo, TX, customs district was third with 12% of the total (table 5).

Imports of soda ash increased to 19,700 t in 2010 and came from 13 countries according to U.S. Census Bureau data. In 2010, 88% of soda ash imports were from: Turkey (51%); China (18%); the United Kingdom (10%); and Mexico (9%). The remaining 12% of imports was from Belgium, Canada, the Dominican Republic, Germany, Hong Kong, India, Italy, Japan, and Romania. The Dominican Republic and Hong Kong were listed as sources; however, both countries do not produce soda ash. It is possible that the entry was erroneous or that the product was transshipped from another location. The average cost, insurance, and freight value of imported soda ash was $292.53 per ton, and the customs value was $249.64 per ton.

World Review

Soda ash is a mature commodity in which consumption tends to increase in proportion to population and gross domestic product growth rates. For this reason, the leading consumers of soda ash were, for the most part, developed nations with lower growth rates compared with those of developing countries. The developing nations tend to use less soda ash than developed nations but have higher growth rates. Although the production and consumption quantities varied among the countries, the end-use patterns were basically the same: glass, chemicals, and detergents were the major sectors.

In 2010, world soda ash production was estimated to be 47.5 Mt, which was a 7% increase from that of 2009. Of the 29 countries that produce natural and synthetic soda ash, the United States was the world's second-ranked producer, accounting for 22% of total world output. Only Botswana, China, Ethiopia, Kenya, Turkey, and the United States produce soda ash from natural sources; the remaining 23 nations manufacture soda ash through various chemical processes, primarily the Solvay process. Total world natural soda ash production represented about 26% of combined world soda ash production.

Eight countries produced more than 1 Mt/yr of soda ash. They were, in descending order, China, the United States, Russia, India, Turkey, Germany, Poland, and France (table 7). Bulgaria, Romania, and Ukraine had production installations that were rated at about 1 Mt/yr; adverse economic conditions, however, caused these nations to produce below their facilities' design capacities. The five top total soda ash-producing nations accounted for 79% of world production in 2010.

India.—The Government decided to reimpose an import duty on soda ash imports from China to reduce imports of less expensive soda ash and to protect its domestic industry. India imposed a 20% duty on imports of soda ash in April 2009 as recommended by India's Directorate General of Safeguards, which was part of the country's finance ministry. The extension of the import duty was expected to be contested by India's detergent and glass industries, which have higher raw material and production costs (Industrial Minerals, 2010).

Saudi Arabia.—Plans were announced in late December for the construction of the first synthetic soda ash plant to be constructed in Jubail II Industrial City, Saudi Arabia. IDEA International Co. planned to build a plant that would produce 500,000 t of soda ash and 575,000 t of calcium chloride annually. About 51 hectares of land had already been acquired for the facility (O'Driscoll, 2010).

Outlook

The country economies that began to turn down in 2008 that affected soda ash-consuming industries throughout 2009, began to slowly recover in 2010. This decrease in soda ash consumption had caused domestic and foreign soda ash producers to reduce soda ash production. However, glass container and flat glass production began to increase, which stimulated world soda ash production and consumption. Three dominant groups have survived to become the world leaders in soda ash—Solvay S.A. of Belgium, ANSAC of the United States (which represented three of the five domestic producers in 2010), and Chinese producers. India has emerged recently as a major leader in world soda ash production as well and will probably compete in the export markets with the other groups. The new natural soda ash facility in Turkey that came onstream in 2009 may double capacity by 2012 to serve markets in the Middle East and northern Africa. This could result in additional competition in that region for U.S. soda ash producers.

With the start of the recovery in the U.S. economy, U.S. soda ash production for 2012 through 2014 is expected to increase. Global economic problems are expected to ease slowly in the next 2 years to stimulate domestic soda ash production and export sales. The United States likely will continue to compete with Chinese soda ash producers in the Far Eastern markets. U.S. soda ash exports in 2011 may increase, causing domestic soda ash production to increase slightly. Increases in world consumption are forecast to range from 2.0% to 2.5% per year for 2012 through 2014. Asia and South America remain the likeliest areas for increased soda ash consumption in the near future.

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TABLE 1

SALIENT SODA ASH STATISTICS[1]

(Thousand metric tons and thousand dollars except average annual value)

	2006	2007	2008	2009	2010
United States:					
Production:					
Soda ash:					
Quantity	11,000	11,100	11,300	9,310	10,600
Value	1,170,000	1,260,000	1,520,000	1,330,000	1,360,000
Value, average annual:					
Per short ton	$96.64	$103.53	$122.11	$129.88	$116.47
Per metric ton	$106.53	$114.12	$134.60	$143.17	$128.39
Wyoming trona	16,700	17,200	17,800	15,100	15,900
Exports:					
Quantity	4,820	5,130	5,370	4,410	5,400
Value	736,000	734,000	939,000	838,000	886,000
Imports for consumption:					
Quantity	7	9	13	6	20
Value	2,290	2,760	3,820	2,350	5,770
Stocks, December 31, producers	290	206	259	217	220
Consumption:					
Apparent	6,100	6,030	5,860	4,950	5,200
Reported	6,110	5,940	5,700	5,020	5,270
World, production[e]	43,700 [r]	45,900 [r]	46,700 [r]	44,300 [r]	47,500

[e] Estimated. [r] Revised.

[1] Data are rounded to no more than three significant digits, except average annual value.

TABLE 2
U.S. PRODUCTION OF SODIUM COMPOUNDS, BY MONTH[1]

(Thousand metric tons)

	2009		2010	
	Soda ash	Wyoming trona[2]	Soda ash	Wyoming trona[2]
January	805	1,160	877	1,530
February	670	2,020	814	1,260
March	739	983	845	1,300
April	670	1,080	876	1,100
May	767	1,180	915	1,410
June	734	1,140	821	1,350
July	794	971	874	1,270
August	827	1,220	948	1,380
September	814	1,250	844	1,280
October	812	1,360	918	1,330
November	826	1,340	911	1,330
December	854	1,380	927	1,420
Total	9,310	15,100	10,600	15,900

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes solution-mined trona.

TABLE 3
U.S. PRODUCERS OF SODA ASH IN 2010

(Million short tons unless otherwise noted)

Company	Plant nameplate capacity	Plant location	Source of sodium carbonate
FMC Wyoming Corp.:			
Granger	1.30	Granger, WY	Underground trona.
Green River[1]	3.55	Green River, WY	Do.
General Chemical (Soda Ash) Partners[2]	2.80	do.	Do.
OCI Chemical Corp.[3]	3.10	do.	Do.
Searles Valley Minerals, Inc.[4]	1.45	Trona, CA	Dry lake brine.
Solvay Chemicals, Inc.:[5]			
Green River	2.80	Green River, WY	Underground trona.
Parachute[6]	1.00	Parachute, CO	Underground nahcolite.
Total	16.00		
Total million metric tons	14.50		

Do., do. Ditto.

[1] Formed joint venture (20%) in February 1996 with Sumitomo Corp. and Nippon Sheet Glass Co., Ltd., both of Japan.

[2] A joint venture between General Chemical Corp. (75%) and Owens-Illinois, Inc. (25%). Tata Chemicals Ltd. of India in January 2008 purchased the 75% share of General Chemical Industrial Products, Inc.

[3] Owned by DC Chemical Co., Ltd. of the Republic of Korea (51%) and Anadarko Petroleum Corp. (49%). An 800,000-short-ton expansion brought onstream in November 1998 increased plant capacity to 3.1 million short tons per year; however, the company took 900,000 short tons per year out of service temporarily for equipment refurbishment.

[4] The operation was sold to Nirma Ltd. of India in November 2007.

[5] Solvay Soda Ash Joint Venture is owned by Solvay S.A. of Belgium (80%) and Asahi Glass Co. of Japan (20%).

[6] Operation purchased on September 10, 2003, from American Soda L.L.P. Soda ash plant idled indefinitely.

TABLE 4

REPORTED CONSUMPTION OF SODA ASH IN THE UNITED STATES, BY END USE, BY QUARTER[1]

(Thousand metric tons)

			2010				
NAICS[2] code	End use	2009	First quarter	Second quarter	Third quarter	Fourth quarter	Total
3272	Glass:						
327213	Container	1,320	323	323	325	312	1,280
327211	Flat	800	219	241	259	247	965
327993	Fiber	141	34	36	35	34	139
327212	Other	111	26	30	31	32	119
	Total	2,370	602	629	650	625	2,510
32518	Chemicals	1,430	371	367	385	396	1,520
325611	Soaps and detergents	508	132	125	133	124	513
322	Pulp and paper	103	22	23	22	21	89
221310	Water treatment[3]	49	12	13	11	10	46
56221	Flue gas desulfurization	152	48	42	54	47	191
422	Distributors	249	67	68	67	70	271
	Other	156	34	36	34	35	138
	Total domestic consumption[4]	5,020	1,290	1,300	1,360	1,330	5,270
	Exports[5]	4,520	1,310	1,350	1,310	1,400	5,360
	Canada	252	63	54	51	64	231
	Total industry sales[6]	9,540	2,590	2,650	2,670	2,730	10,600
	Total sales from plants	9,450	2,610	2,690	2,720	2,770	10,800
	Total production	9,310	2,540	2,610	2,670	2,760	10,600

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] North American Industry Classification System.

[3] Includes soda ash equivalent from soda liquors and purge liquors sold to powerplant for water treatment. Sales of mine water are excluded.

[4] Imports reported by the producer/importer have been distributed into appropriate end-use categories listed above.

[5] As reported by producers; includes Canada. Data may not necessarily agree with those reported by the U.S. Census Bureau for the same periods.

[6] Represents soda ash from domestic origin (production and inventory changes) and imports and exports. Includes soda ash sold by coproducers and distributed by purchasers into appropriate end-use categories.

TABLE 5

REGIONAL DISTRIBUTION OF U.S. SODA ASH EXPORTS, BY CUSTOMS DISTRICTS, IN 2010[1]

(Metric tons)

Customs districts	North America	Central America	South America	Caribbean	Europe	Middle East	Africa	Asia	Oceania	Total	Percentage of total
Atlantic:											
Miami, FL	--	173	263	116	--	--	--	--	--	552	(2)
New York, NY	--	--	--	--	353	--	--	7	--	360	(2)
Norfolk, VA	--	--	--	--	196	--	--	--	--	196	(2)
Philadelphia, PA	--	--	--	--	24	--	--	--	--	24	(2)
Savannah, GA	--	--	36	--	176	--	--	--	--	212	(2)
Gulf:											
Houston-Galveston, TX	--	20	11,100	16	205	--	253	--	--	11,600	(2)
Mobile, AL	--	--	--	--	28	--	--	--	--	28	(2)
New Orleans, LA	--	--	19	--	--	--	--	--	--	19	(2)
Port Arthur, TX	--	10,500	882,000	1,000	442,000	24,700	312,000	8,240	--	1,680,000	31
North-central:											
Chicago, IL	--	--	--	--	--	--	--	46	--	46	(2)
Cleveland, OH	14	--	--	--	32	--	--	--	--	46	(2)
Detroit, MI	185,000	--	--	--	62	--	--	--	--	185,000	3
Duluth, MN	3,360	--	--	--	--	--	--	--	--	3,360	(2)
Great Falls, MT	23,300	--	--	--	--	--	--	--	--	23,300	(2)
Pembina, ND	2,960	--	--	--	--	--	--	--	--	2,960	(2)
Northeast:											
Buffalo, NY	11,800	--	--	--	--	--	--	--	--	11,800	(2)
Ogdensburg, NY	1,330	--	--	--	--	--	--	--	--	1,330	(2)
Portland, ME	89	--	--	--	--	--	--	--	--	89	(2)
Pacific:											
Anchorage, AK	6,120	--	--	--	--	--	--	--	--	6,120	(2)
Columbia-Snake River, ID-OR-WA	--	60,700	327,000	--	166,000	188,000	--	1,460,000	116,000	2,310,000	43
Los Angeles, CA	--	19	298,000	--	5,450	1,350	20	2,240	80	307,000	6
San Diego, CA	58,900	--	--	--	--	--	--	--	--	58,900	1
Seattle, WA	18,000	--	--	--	--	--	--	524	--	18,500	(2)
Southwest:											
Dallas-Fort Worth, TX	--	--	--	--	--	--	7	--	--	7	(2)
El Paso, TX	142,000	--	--	--	--	--	--	--	--	142,000	3
Laredo, TX	622,000	--	--	--	--	--	--	--	--	622,000	12
Unknown	444	--	--	--	--	--	--	--	--	444	(2)
Total	1,080,000	71,400	1,520,000	1,130	615,000	214,000	312,000	1,470,000	116,000	5,400,000	100
Percentage of total	20	1	28	(2)	11	4	6	27	2	100	XX

XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau, as adjusted by the U.S. Geological Survey using data and information from the Journal of Commerce PIERS trade service and industry sources.

TABLE 6
U.S. EXPORTS OF SODA ASH, BY COUNTRY[1]

Country	2009 Quantity (thousand metric tons)	2009 Value[2] (thousands)	2009 Unit value	2010 Quantity (thousand metric tons)	2010 Value[2] (thousands)	2010 Unit value
Argentina	116	$24,500	$211	82	$13,100	$160
Australia	92	20,200	220	87	15,800	182
Bahrain	--	--	--	1	168	168
Belgium	234	36,500	156	175	22,300	128
Brazil	506	104,000	205	701	113,000	161
Canada	272	56,700	208	253	52,400	207
Chile	212	41,600	196	272	45,300	167
China	32	2,070	65	--	--	--
Colombia	68	13,800	203	128	19,100	150
Costa Rica	27	7,010	260	19	3,640	192
Dominican Republic	6	1,500	250	1	173	173
Ecuador	23	5,430	236	27	4,160	154
Egypt	6	605	101	25	2,690	107
El Salvador	6	1,320	220	10	1,670	167
France	56	7,920	141	42	6,080	145
Guatemala	19	4,150	218	35	6,080	174
India	3	660	220	8	1,730	216
Indonesia	282	41,800	148	457	64,100	140
Italy	10	1,730	173	--	--	--
Japan	213	41,200	193	229	33,200	145
Korea, Republic of	138	25,100	182	229	35,900	157
Lithuania	72	10,200	142	122	16,700	137
Malaysia	31	5,990	193	49	8,540	174
Mexico	758	171,000	225	823	175,000	212
Namibia	--	--	--	2	263	132
Netherlands	166	28,600	172	137	18,700	137
New Zealand	25	5,010	200	29	4,920	170
Panama	9	2,100	233	8	1,430	179
Peru	43	9,110	212	57	9,010	158
Philippines	43	6,250	145	62	9,070	146
Portugal	62	7,560	122	49	5,960	122
Saudi Arabia	117	20,300	173	116	15,200	131
South Africa	82	13,300	162	162	18,100	112
Spain	116	17,300	149	61	8,440	138
Taiwan	160	25,200	157	252	39,600	157
Thailand	148	24,200	163	142	18,800	133
Tunisia	33	3,760	114	149	17,900	120
United Arab Emirates	58	11,400	196	72	11,400	158
United Kingdom	--	--	--	29	5,350	185
Venezuela	158	38,900	246	252	55,500	220
Vietnam	6	823	137	38	5,370	141
Other	1 r	407 r	407 r	1	274	274
Total	4,410	838,000	190	5,400	886,000	164

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Free alongside ship value.

Source: U.S. Census Bureau, as adjusted by the U.S. Geological Survey using data and information from the Journal of Commerce Port Import-Export Reporting Service and industry sources.

TABLE 7
SODA ASH: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Thousand metric tons)

Country[3]	2006	2007	2008	2009	2010
Argentina	161 [4]	--	--	--	--
Australia	310	310	310	310	310
Bosnia and Herzegovina	11	11	11	11	11
Botswana[5]	250	250	250	250	250
Brazil	200	200	200	200	200
Bulgaria	800	800	800	800	800
Chad[6]	12	12	12	12	12
China	15,600 [4]	17,720 [4]	18,540 [r, 4]	19,350 [4]	20,290 [4]
Egypt	50	50	50	50	50
Ethiopia[7]	4	(8) [4]	4 [r, 4]	4 [r, 4]	5
France	1,000	1,000	1,000	1,000	1,000
Germany	2,587 [r, 4]	2,595 [r, 4]	2,715 [r, 4]	2,291 [r, 4]	2,539 [4]
India	1,500	1,500	1,500	1,500	1,500
Iran	130	140	140	140	140
Italy	500	500	500	500	500
Japan	400	400	400	400	400
Kenya[5]	374 [r, 4]	387 [4]	513 [4]	405 [4]	460 [4]
Korea, Republic of	310	310	310	310	310
Mexico	290	290	290	290	290
Netherlands	400	400	400	400	400
Pakistan	250	260	250	260	250
Poland	1,177 [4]	1,192 [4]	1,190	890	1,000
Portugal	150	150	150	150	150
Romania	453	453	450	400	450
Russia	2,800	2,900	2,800	2,300	2,400
Spain	500	500	500	500	500
Turkey[9]	891 [4]	947 [4]	949 [r, 4]	1,079 [r, 4]	1,500
Ukraine	700	700	700	700	700
United Kingdom	900	900	500	500	500
United States[5]	11,000 [4]	11,100 [4]	11,300 [4]	9,310 [4]	10,600 [4]
Total	43,700 [r]	45,900 [r]	46,700 [r]	44,300 [r]	47,500

[r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through April 20, 2011. Synthetic unless otherwise specified.

[3] In addition to the countries listed, Tanzania may produce soda ash for local consumption; available general information is inadequate for the formulation of reliable estimates of output levels.

[4] Reported figure.

[5] Natural only.

[6] Produced for local consumption only.

[7] Data for the Ethiopian calendar year ending July 7 of the year listed.

[8] Less than ½ unit.

[9] Production of natural soda ash from Beypazari deposit began in early 2009.

STONE, CRUSHED

By Jason Christopher Willett

Domestic survey data were prepared by Susan M. Weaver, Denise Nguyen, Glenn W. Walker, and Robert H. Bradley, statistical assistants.

A total 1.16 billion metric tons (Gt) of crushed stone was produced for consumption in the United States in 2010, virtually unchanged from the total production of 2009 and 35% less than the record high of 1.78 Gt in 2006. In 2010, the total value of crushed stone produced in the United States was $11.2 billion, a slight decrease compared with that of 2009 and 22% less than that of 2006 (table 1). The average unit price for crushed stone decreased slightly compared with the average unit price for 2009 but was 21% higher compared with that of 2006. In 2010, the crushed stone industry experienced the lowest level of crushed stone production for consumption in the United States since 1993, with the lowest total value since 2004.

About 70% of crushed stone production was limestone and dolomite, followed by (in descending order of tonnage) granite, traprock, miscellaneous stone, sandstone and quartzite, marble, slate, calcareous marl, volcanic cinder and scoria, and shell (table 2).

Foreign trade in crushed stone remained relatively small compared to nationwide consumption. In 2010, U.S. exports decreased by 4% to 1.21 million metric tons (Mt) compared with 1.26 Mt in 2009, and the value decreased by 11% to $52.1 million, compared with $58.3 million in 2009 (tables 1, 17). U.S. imports of crushed stone, including calcium carbonate fines, increased by 19% to 14.6 Mt, and the value increased by 6% to $185 million compared with the 2009 totals (tables 1, 18). Apparent domestic consumption of crushed stone, which is defined as production for consumption (sold or used) plus recycling and imports minus exports, was virtually unchanged compared with that of 2009 because of the very slight decrease in production for consumption of crushed stone in the United States in 2010.

Stone is one of the most accessible natural resources on Earth and one of the fundamental building blocks of society. It has been used from the earliest times of civilization in a variety of ways that have increased in number and complexity with time and technological progress. Today, in its crushed form, stone is a major basic raw material for the construction industry, as well as agriculture and other industries that use complex chemical and metallurgical processes. Despite the relatively low, but increasing, unit value of its basic products, the crushed stone industry is a major contributor to and an indicator of the economic well-being of the Nation. Construction aggregates are defined as the combination of crushed stone and construction sand and gravel. The construction sand and gravel industry is reviewed in a separate chapter, and both mineral commodities are usually included in any review of national or State aggregates industry.

Production

Domestic production data for crushed stone were derived by the U.S. Geological Survey (USGS) from voluntary surveys of U.S. producers. In 2010, a total of 1,598 companies produced or sold crushed stone from 3,953 operations with 3,897 quarries and 207 sales and (or) distribution sites. Of the 3,953 active operations, 2,295 operations reported their production or sales to the USGS, and their total production was 843 Mt (73% of the U.S. total). Of the 2,295 reporting operations, 1,199 operations did not report a breakdown by end use. Their total production was 310 Mt (27% of the U.S. total) and is included in table 9 under "Unspecified, reported" uses.

Production of the nonresponding quarries was estimated by using employment data provided by the Mine Safety and Health Administration (MSHA). The estimated output of 1,519 nonrespondent operations was 314 Mt (27% of the U.S. total) and is included in table 9 under "Unspecified, estimated" uses.

A total of 207 sales yards were active in 2010, and the total quantity of crushed stone sold was 40.3 Mt. Information regarding the number of active operations, including recycling operations, active quarries, type of processing plants, and number of sales yards by State is provided in table 16.

Crushed stone was produced in every State except Delaware. Starting with 2005, Delaware's production is included in the U.S. total because of sales yards that reported sales of crushed stone in the State. The 10 leading producing States were, in descending order of tonnage, Texas, Pennsylvania, Missouri, Illinois, Kentucky, Ohio, Indiana, Virginia, Georgia, and Florida. The combined production of the 10 leading States increased by 2% and was 594 Mt, more than one-half of the national total.

There are 93 underground mines included in the total number of active operations, and they produced 68.7 Mt of crushed stone in 2010. Active underground mines were located in 17 States. The five leading States were, in descending order of tonnage, Kentucky, Missouri, Illinois, Pennsylvania, and Iowa. Their combined production was 48.2 Mt (70% of the total of U.S. crushed stone produced underground).

A total of 1,076 crushed stone operations were either idle or presumed to have been idle in 2010 because no production report was received, and no employment information was available to estimate their production. Since the 2009 survey, 113 operations have closed. Most of the idle or closed operations were small, temporary quarries, some of which were operated by State or local governments. Operations in U.S. territories are not included in the above count.

Of the total 1.16 Gt of crushed stone produced for consumption in the United States in 2010, 70% was limestone and dolomite; 14% was granite; 6% was traprock; 5% was miscellaneous stone; and 4% was sandstone and quartzite. The remaining 1% was shared, in descending order of tonnage, by marble, slate, calcareous marl, volcanic cinder and scoria, and shell. These percentages were calculated on the total amount of crushed stone produced for consumption that was reported, including individual amounts that were withheld to avoid disclosing company proprietary data (table 2).

A review of production by size of operation at the national level indicates that, in 2010, 455 Mt of crushed stone (39% of the total crushed stone) was produced by 275 operations reporting production of more than 1 million metric tons per year; 294 Mt was produced by 475 operations reporting production between 500,000 and 999,999 metric tons per year (t/yr); and 356 Mt was produced by 1,512 operations reporting production between 100,000 and 499,999 t/yr. Operations that produced more than 500,000 t/yr accounted for 65% of total crushed stone produced in the United States in 2010, a slight increase compared with that of 2009 (table 5a). By geographic region, in 2010, the South had 1,305 active operations, followed by the Midwest with 1,080, the West with 797, and the Northeast with 582 active operations (table 5b).

The leading U.S. producing companies in 2010 were, in descending order of tonnage, Vulcan Materials Co.; Martin Marietta Aggregates; Lehigh Hanson, Inc.; Oldcastle Materials, Inc.; Lafarge North America Inc.; CEMEX S.A.B. de C.V.; Carmeuse Lime & Stone; Rogers Group, Inc.; Holcim Group/Aggregate Industries Management, Inc.; and New Enterprise Stone & Lime Co., Inc. The combined production of the top 10 companies was 562 Mt (49% of the national total). The combined production of the top 100 companies was 914 Mt (79% of the national total).

Merger and acquisition activity in the U.S. construction aggregates industry, after the huge acquisitions that took place in 2007, slowed to a much lower level and then came to a stop in 2009. The lack of activity continued throughout 2009 as companies focused resources on restructuring debt, raising capital, and strengthening core assets (Aggregates Manager, 2010c). The refocusing of resources had been the common theme since mid-2009, but the trend may have begun to change after a few quarters in 2010, with increased consumption (Willett, 2011).

CEMEX S.A.B. de C.V. committed to reducing debt in 2010 by selling off assets in five States, mostly in the Eastern United States. CEMEX announced the sale of seven quarries, three salesyards, and one concrete block plant in Kentucky to Bluegrass Materials Co., LLC (Aggregates Manager, 2010b). These assets were acquired when CEMEX purchased Rinker Group Ltd. in 2007 (Rock Products, 2010). Later in the year, the company sold three quarries in Wyoming plus its remaining stake in Granite Canyon Quarry to Martin Marietta Aggregates (Aggregates Manager, 2010a). From its joint venture with Ready Mix USA, LLC, CEMEX sold the combined total of 2 granite quarries and 20 limestone quarries in the States of Georgia, Tennessee, and Virginia (Aggregates Manager, 2010b).

Summit Materials, LLC completed purchases in nine States during 2010 to increase its construction materials business. Summit purchased Altaview Concrete, Inc.; B&B Resources, Inc.; and Harper-Kilgore, LLC to add to its construction aggregates and ready-mix concrete assets in Utah (Summit Materials, 2010b). Summit also purchased RK Hall, a construction aggregates and asphalt producer with operations in Arkansas, Oklahoma, and Texas. Con-Agg of MO, LLC (Con-Agg), an aggregates and ready-mix concrete company based in Missouri, was purchased by Summit along with Fischer Quarries, LLC, also based in Missouri (Summit Materials, 2010c). Summit also made purchases in Colorado, Idaho, and Wyoming of Elam Construction, Inc.; Grand Junction Concrete Pipe, Inc.; Triple C Concrete, Inc.; and Wind River Materials, LLC (Summit Materials, 2010a).

Lafarge North America Inc. and Titan America LLC sold assets in 2010. Dolese Bros. Co; Luck Stone Corp.; Martin Marietta; Oldcastle Materials, Inc.; and VantaCore Partners LP made small acquisitions. Oldcastle Materials completed two small acquisitions with the purchase of the construction materials assets of A.L. Blades & Sons, Inc. (Hornell, New York) and MAC Construction, Inc. (Virginia) to add on to its asphalt paving and construction business (Aggregates Manager, 2010b, 2011).

Production of crushed stone by type is detailed below.

Calcareous Marl.—Output of calcareous marl increased 5% compared with that of 2009 to 2.7 Mt valued at $21.4 million (table 2).

Dolomite.—Production of dolomite decreased by 5% compared with the total for 2009 to 48.9 Mt valued at $470 million (table 2). Crushed dolomite production was reported in 25 States. The leading producing States were, in descending order of tonnage, Pennsylvania, Illinois, New York, Michigan, and Indiana; the total production of these five States was 36.2 Mt (74% of the U.S. output) (table 6). An additional undetermined amount of dolomite is included in the total crushed limestone, as explained in the limestone portion of the "Production" section.

Granite.—The output of crushed granite decreased by 3% compared with that of 2009 to 157 Mt valued at $1.8 billion (table 2). Crushed granite was reported as being produced in 34 States. The leading producing States were, in descending order of tonnage, Georgia, North Carolina, Virginia, South Carolina, and California; the total production of these five States was 106 Mt (67% of the U.S. output) (table 7).

Limestone.—The output of crushed limestone, including some dolomite, increased slightly compared with that of 2009 to 756 Mt valued at $6.8 billion (table 2). Limestone production was reported in 47 States, and companies in 22 States reported producing limestone and dolomite from the same quarries. Their production of about 18.8 Mt of limestone and dolomite combined is included with the limestone listed in table 2. The limestone totals listed in this chapter, therefore, include an undetermined amount of dolomite in addition to the dolomite reported separately. The leading producing States were (in descending order of tonnage) Texas, Missouri, Kentucky, Pennsylvania, and Ohio; the total production of these five States was 309 Mt (41% of the total U.S. output) (table 6).

Marble.—Production of crushed marble decreased by 28% compared with the total for 2009 to 6.5 Mt valued at $86.1 million (table 2). Crushed marble production was reported in 15 States.

Miscellaneous stone.—This category includes three different types of miscellaneous crushed stone production. The first type is a crushed stone, which was reported by the company as "other" on the survey form or as a type of stone not listed on table 2. The second type is production of unknown stone type from a company or operation that is new to the survey. The first year an operation is added to the survey, its production is often estimated using MSHA employment data. The type of stone produced is updated when a response is received from the operation and the data are revised for the next report. The third type is production of a known rock type when the amount reported must be withheld to protect company proprietary data. The concealed amount is added to the quantity of miscellaneous stone produced in that State and then published.

The output of miscellaneous stone decreased by 7% compared with the total for 2009 to 59.7 Mt, valued at $503 million (table 2). In 2010, the reported amount of miscellaneous stone accounted for 67% of the total output of miscellaneous stone and 60% of its value (table 13). The remaining 33% (29.8 Mt) of the total output consisted of known stone for which data were withheld. Of the 29.8 Mt, 57% was limestone and traprock, with the remaining 43% consisting of (in descending order of tonnage) granite, marble, sandstone and quartzite, slate, volcanic cinder and scoria, shell, dolomite, and calcareous marl.

Sandstone and Quartzite.—The output of crushed sandstone and quartzite was virtually unchanged compared with the total for 2009 at 43.8 Mt, valued at $416 million (table 2). Crushed sandstone production was reported in 30 States, while quartzite was produced in 17 States. The leading producing States were (in descending order of combined tonnage of sandstone and quartzite) Pennsylvania, Arkansas, Texas, South Dakota, and New York. Their combined total production was 28.7 Mt (66% of the U.S. output) (table 7).

Shell.—Shell is derived mainly from fossil reefs or oyster shell banks. The output of crushed shell more than tripled compared with the total for 2009 to 1.7 Mt, valued at $24.6 million (table 2). Crushed shell was reported as being produced in three States.

Slate.—The output of crushed slate increased by 6% compared with that of 2008 to 3.2 Mt, valued at $34.4 million (table 2). Crushed slate was produced in 10 States, with Pennsylvania accounting for about 37% of the total U.S. output.

Traprock.—Production of crushed traprock increased very slightly compared with the total for 2009 to 73.9 Mt, valued at $927 million (table 2). Traprock was reported as being produced in 27 States. The leading producing States were (in descending order of tonnage) New Jersey, Oregon, Virginia, Washington, and North Carolina; these five States produced 35.8 Mt (48% of U.S. output) (table 7).

Volcanic Cinder and Scoria.—Production of volcanic cinder and scoria decreased by 72% compared with the total for 2009 to 2.3 Mt, valued at $17.8 million (table 2). Volcanic cinder and scoria production was reported in 13 States, with the top producing State of Wyoming accounting for 49% of U.S. output (table 8).

Consumption

Crushed stone production reported to the USGS is actually material that was either sold to other companies or consumers or was used by producers. Stockpiled production is not included in the reported quantities. The "sold or used" tonnage, therefore, represents the amount of production released for domestic consumption or export in a given year. Because some of the crushed stone producers did not report a breakdown by end use, their total production is included in the "Unspecified, reported" use category. The estimated production of nonrespondents is included in the "Unspecified, estimated" use category.

In 2010, U.S. apparent consumption of crushed stone, which is defined as U.S. production plus imports and recycled material minus exports, was 1.20 Gt, almost unchanged compared with the apparent consumption in 2009. Of the 1.20 Gt of crushed stone consumed, 310 Mt (27%) was "Unspecified, reported," and 314 Mt (27%) was "Unspecified, estimated." Of the remaining consumption reported by uses, 80% was used as construction aggregate, mostly for highway and road construction and maintenance, as well as for a wide variety of building and other nonbuilding construction; 10% for cement manufacturing; 3% for lime manufacturing; 2% for agricultural uses; and 2% for special and miscellaneous uses and products (table 9). It is indicated that, in marketing analysis or use-pattern studies, the quantities included in unspecified uses may be prorated and added to the reported uses by applying the above percentages calculated for the reported quantities. Using this procedure, the analyst assumes that the breakdown by uses of the unspecified uses is similar to that of the reported uses.

In 2010, the value of the total construction put in place decreased by 11% compared with that of 2009 to $804 billion, as reported by the U.S. Census Bureau (2011). The value of total private construction decreased by 15% to $501 billion. This was the fourth consecutive drop in the total value of private construction and the lowest level since 1997. The value of total public construction decreased by 4% to $303 billion, which was the first decrease in total value in more than 18 years.

Additional information regarding production and consumption of crushed stone by type of rock and major uses in each State and the State districts may be found in the USGS Minerals Yearbook, volume II, Area Reports: Domestic.

Recycling

The recycling of many materials was expanding, and aggregates producers were increasingly recycling cement concrete and asphalt concrete materials recovered from construction projects to be reused to produce aggregate materials, especially fill and road base. The recycling of cement concrete is done at some quarries and increasingly at sales yards or distribution sites, whereas asphalt concrete often is recycled in place. The USGS surveyed construction aggregate mining companies, construction companies, and demolition companies, which reported the following data. The data represents an unknown percentage of the actual U.S. total of recycled construction aggregates.

Recycled Asphalt.—Companies in 48 States reported a total of 11.4 Mt of recycled asphalt, valued at $119 million in 2010 (table 14). The leading recycling States were (in descending order of tonnage) California, Kansas, North Carolina, Michigan, and Illinois. Their combined total was 5.4 Mt, a decrease of 8% compared with their combined total in 2009.

Recycled Concrete.—A total of 13.4 Mt of recycled concrete valued at $98.6 million was reported as recycled in 48 States (table 15). The leading recycling States for 2010 were (in descending order of tonnage) California, Wisconsin, Michigan, Illinois, and Virginia. Their combined total was 7.3 Mt, an increase of 47% compared with their combined total of 2009.

Prices

Prices in this chapter are the annual average free on board plant prices, usually at the first point of sale or captive use, as reported by crushed stone producing companies. This value does not include transportation from the plant or yard to the consumer. It does, however, include all costs of mining, processing, in-plant transportation, overhead costs, and profit. In 2010, 825 operations responding to the annual survey reported the dollar value of their production for the current and previous year. The average unit value for operations reporting production and value was $10.02 per metric ton in 2010. This was a slight decrease compared with the average unit value of $10.16 per ton in 2009. The annual reports of the top U.S. producing companies reported a 2% to 4% price decrease in 2010, compared with prices in 2009. For those operations that reported production only, the unit values of total production or specific end uses were estimated based on what other operations in the same State reported. The average unit value for specific end uses within a State was used in the estimation of value for operations reporting specific end uses. The State average was used in the estimation for operations reporting total production but not total value.

Additional information regarding prices of crushed stone by type of rock and uses in the United States and each State and the State districts may be found throughout the tables included in this chapter and in the USGS Minerals Yearbook, volume II, Area Reports: Domestic.

Transportation

For 672 Mt of the 1.16 Gt of crushed stone produced for consumption in 2010, no means of transportation was reported by the producers. Of the remaining 483 Mt of crushed stone, 62% was reported as being transported by truck from the quarry or the processing plant to the first point of sale or use; 4% by rail; and 6% by waterway. About 126 Mt of the specified production was reported as not having been transported and, therefore, is assumed to have been used onsite.

Shipment by truck remains the most widely used method of transportation for crushed stone. The significant increase in the number of sales and distribution yards in the past few years and the increase in the volume of crushed stone going through these sites have had a positive impact on the industry and the communities they serve. Distribution yards, supplied by rail or waterway, are located near metropolitan areas and significantly reduce the distance most trucks must travel to pick up and deliver crushed stone. Therefore, the transportation costs are reduced, as is the impact of heavy traffic on the infrastructure and the environment. Sales yards serve to distribute products and, increasingly, also serve as recycling sites.

Foreign Trade

The widespread distribution of domestic deposits of stone suitable for mining as crushed stone, the large number of existing active operations around the country, and the high cost of transportation limit foreign trade to mostly local transactions across international boundaries. U.S. imports and exports continue to be small, representing slightly more than 1% of domestic consumption.

Information on imports of crushed stone used for this report was derived from two sources. The primary source was import and export data from the U.S. Census Bureau (tables 1, 17–18). Additionally, companies provided import data when reporting the amount sold or used for consumption at each operation, usually a sales yard. The tonnage reported was attributed to the State where it was first sold or used; for example, crushed stone imported to Florida from Mexico was counted in the total of crushed stone sold or used in Florida (table 4). This was the same accounting practice used for large quantities of crushed stone, which were transported from one State to another. For example, crushed stone mined in Kentucky and shipped down the Mississippi River to be used in Louisiana was included in the total of crushed stone sold or used in Louisiana.

Exports.—Exports of crushed stone decreased by 4% to 1.21 Mt compared with the total of 1.26 Mt in 2009, with the value decreasing by 11% to $52.1 million. In 2010, exports of crushed limestone for cement manufacturing averaged a unit value of $21.62 per ton, which was lower than the average unit value of 2009 (table 17).

Imports.—Imports of crushed stone increased by 19% to 14.6 Mt compared with those of 2009, and the value increased by 6% to $185 million. Of the imported crushed stone, almost all of it was limestone used as construction aggregate, as flux stone, and in cement manufacturing (table 18).

Outlook

The crushed stone industry is a cyclical business, reacting to the levels of activity in public infrastructure projects, commercial and residential construction markets, and other types of construction. The residential construction slowdown in the United States was well documented and led to decreased consumption of crushed stone. The decline in residential construction appeared to level off in late 2010 and modest improvements are expected in 2011. Based on quarterly sales data, it is thought that the construction industry reached the low point in the cycle and was starting to recover (Willett, 2011).

Even with the uncertainty in the economic and political climate in the United States, many construction aggregates producers expect to see improvements in production levels in 2011. It has been predicted that almost one-third of the American Recovery and Reinvestment Act of 2009 funds will be spent in 2011, and this could contribute to increased consumption of construction materials (Martin Marietta, 2011, p. 5; Vulcan Materials, 2011, p. 25). Increased consumption of crushed stone in commercial construction combined with State highway and infrastructure projects may offset the continuing decline in residential construction. Increased consumption in 2011 from that in 2010, is not expected to reach the historical annual average of the past 50 years of 2% to 4%. However, the estimated output of crushed stone in the 48 conterminous States shipped for consumption in the first 6 months of 2011 was 507 Mt, a 4% decrease compared with that of the same period of 2010. Second quarter shipments of crushed stone for consumption decreased by 6.5% compared with those of the same period of 2010 (Willett, 2011). This might indicate that the recovery might take longer than previously expected.

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TABLE 1

SALIENT CRUSHED STONE STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2006	2007	2008	2009	2010
Sold or used by producers:[2]					
Quantity	1,780,000	1,650,000 [r]	1,460,000 [r]	1,160,000 [r]	1,160,000
Value	14,300,000	14,100,000 [r]	13,600,000 [r]	11,300,000 [r]	11,200,000
Recycle:					
Quantity	15,400	20,100	29,100	28,500 [r]	24,900
Value	111,000	150,000	252,000	264,000 [r]	218,000
Exports:					
Quantity	1,140	1,020	1,240	1,260	1,210
Value	57,300	62,500	61,600	58,300	52,100
Imports for consumption:[3]					
Quantity	19,800	19,500	20,900	12,200	14,600
Value	206,000	212,000	232,000	174,000	185,000

[r] Revised; estimated quantities for the prior year have been recalculated.

[1] Data are rounded to no more than three significant digits.

[2] Does not include American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands.

[3] Excludes precipitated calcium carbonate.

TABLE 2

CRUSHED STONE SOLD OR USED IN THE UNITED STATES, BY TYPE[1, 2]

Type	2009[3] Number of quarries	2009[3] Quantity (thousand metric tons)	2009[3] Value (thousands)	2009[3] Unit value	2010 Number of quarries	2010 Quantity (thousand metric tons)	2010 Value (thousands)	2010 Unit value
Limestone[4]	2,160	744,000	$6,650,000	$8.94	2,080	756,000	$6,830,000	$9.03
Dolomite	145	51,700	521,000	10.08	164	48,900	470,000	9.62
Marble	38	9,030	120,000	13.27	42	6,490	86,100	13.27
Calcareous marl	5	2,590	14,700	5.68	4	2,720	21,400	7.88
Shell	6	464	8,450	18.20	8	1,730	24,600	14.24
Granite	425	162,000	1,950,000	12.09	427	157,000	1,840,000	11.74
Traprock	354	73,800	989,000	13.39	346	73,900	927,000	12.55
Sandstone and quartzite[5]	220	43,700	423,000	9.68	211	43,800	416,000	9.51
Slate	40	2,980	30,900	10.36	37	3,150	34,400	10.95
Volcanic cinder and scoria	48	8,330	48,300	5.80	44	2,340	17,800	7.63
Miscellaneous stone	565	64,200	563,000	8.77	533	59,700	503,000	8.42
Total or average	XX	1,160,000	11,300,000	9.74	XX	1,160,000	11,200,000	9.67

XX Not applicable.

[1] Data are rounded to no more than three significant digits, except unit values and number of quarries; may not add to totals shown.

[2] Does not include American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands.

[3] Estimated quantities for the prior year have been recalculated.

[4] Includes limestone-dolomite reported with no distinction between the two kinds of stone.

[5] Includes sandstone-quartzite reported with no distinction between the two kinds of stone.

TABLE 3

CRUSHED STONE SOLD OR USED IN THE UNITED STATES, BY GEOGRAPHIC DIVISION[1, 2]

(Thousand metric tons and thousand dollars)

Region/division	2009[3] Quantity	2009[3] Value	2010 Quantity	2010 Value
Northeast:				
New England	35,100	387,000	33,000	362,000
Middle Atlantic	134,000	1,560,000	133,000	1,540,000
Total	169,000	1,950,000	166,000	1,900,000
Midwest:				
East North Central	188,000	1,490,000	189,000	1,410,000
West North Central	142,000	1,260,000	139,000	1,230,000
Total	329,000	2,760,000	328,000	2,640,000
South:				
South Atlantic	221,000	2,760,000	227,000	2,810,000
East South Central	126,000	1,260,000	128,000	1,290,000
West South Central	182,000	1,400,000	191,000	1,480,000
Total	529,000	5,420,000	545,000	5,570,000
West:				
Mountain	56,400	433,000	47,700	383,000
Pacific	77,800	761,000	69,100	683,000
Total	134,000	1,190,000	117,000	1,070,000
Grand total	1,160,000	11,300,000	1,160,000	11,200,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Does not include American Samoa, Guam, Puerto Rico, and the U.S. Virgin Islands.

[3] Estimated quantities for the prior year have been recalculated.

TABLE 4

CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE AND TERRITORIES[1]

	2009[2]			2010		
State	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Alabama	35,700	$327,000	$9.15	35,400	$331,000	$9.36
Alaska	1,940	34,700	17.93	1,510	22,600	14.97
Arizona	9,520	88,700	9.32	8,280	80,300	9.70
Arkansas	29,400	215,000	7.31	31,000	238,000	7.66
California	39,800	377,000	9.45	31,700	313,000	9.86
Colorado	6,800	62,200	9.14	7,320	58,400	7.98
Connecticut	8,160	102,000	12.54	7,250	92,700	12.78
Delaware[3]	W	W	W	W	W	W
Florida	41,200	558,000	13.54	42,800	548,000	12.79
Georgia	44,500	510,000	11.46	42,900	466,000	10.86
Hawaii	5,800	101,000	17.35	4,750	91,900	19.37
Idaho	3,880	26,600	6.85	4,030	23,900	5.95
Illinois	56,900	514,000	9.04	53,100	477,000	8.98
Indiana	44,200	290,000	6.56	44,300	291,000	6.57
Iowa	32,700	298,000	9.13	31,800	292,000	9.16
Kansas	16,900	142,000	8.38	16,800	143,000	8.51
Kentucky	47,000	415,000	8.84	49,200	425,000	8.65
Louisiana[3]	W	W	W	W	W	W
Maine	3,600	31,600	8.79	3,430	30,200	8.80
Maryland	23,300	208,000	8.93	21,700	221,000	10.17
Massachusetts	11,200	130,000	11.56	10,400	120,000	11.46
Michigan	20,400	116,000	5.69	21,900	122,000	5.55
Minnesota	7,440	92,300	12.40	7,350	90,200	12.27
Mississippi[3]	3,130	63,400	20.25	2,910	65,500	22.54
Missouri	72,800	639,000	8.77	70,200	595,000	8.48
Montana	1,990	20,400	10.25	2,020	21,200	10.50
Nebraska	6,200	59,200	9.54	6,760	70,100	10.37
Nevada	7,380	81,300	11.01	6,970	80,800	11.58
New Hampshire	4,800	47,600	9.93	4,320	39,500	9.14
New Jersey	14,500	124,000	8.51	14,400	119,000	8.27
New Mexico	6,000	39,400	6.57	4,280	34,100	7.97
New York	38,000	431,000	11.35	33,000	367,000	11.12
North Carolina	38,700	587,000	15.15	40,500	591,000	14.59
North Dakota	985	3,980	4.05	835	3,770	4.52
Ohio	43,300	395,000	9.12	47,200	394,000	8.36
Oklahoma	36,100	301,000	8.34	39,000	343,000	8.80
Oregon	15,500	118,000	7.60	16,300	122,000	7.49
Pennsylvania	81,500	1,000,000	12.31	85,500	1,050,000	12.29
Rhode Island	1,820	20,200	11.09	1,440	15,800	10.95
South Carolina	18,200	201,000	11.01	19,200	215,000	11.23
South Dakota	4,540	29,900	6.58	4,890	32,200	6.59
Tennessee	40,300	453,000	11.25	40,900	464,000	11.35
Texas	110,000	788,000	7.15	114,000	807,000	7.05
Utah	4,790	39,100	8.17	5,840	43,800	7.50
Vermont	5,480	55,900	10.21	6,080	64,100	10.53
Virginia	42,300	580,000	13.70	44,100	613,000	13.88
Washington	14,800	132,000	8.93	14,800	133,000	9.02
West Virginia	12,300	112,000	9.07	14,700	141,000	9.62
Wisconsin	23,100	179,000	7.75	22,600	130,000	5.77
Wyoming	16,000	75,400	4.71	8,910	40,300	4.52
Other	6,550	102,000	15.60	6,730	102,000	15.11
U.S. total or average	1,160,000	11,300,000	9.74	1,160,000	11,200,000	9.67

See footnotes at end of table.

TABLE 4—Continued

CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE AND TERRITORIES[1]

State	2009[2] Quantity (thousand metric tons)	2009[2] Value (thousands)	2009[2] Unit value	2010 Quantity (thousand metric tons)	2010 Value (thousands)	2010 Unit value
Territory						
American Samoa[4]	(5)	(5)	(5)	(5)	(5)	(5)
Guam	296	$3,060	$10.35	114	$1,180	$10.35
Puerto Rico	9,450	72,400	7.67	8,060	68,200	8.46
Virgin Islands	(5)	(5)	(5)	(5)	(5)	(5)
Grand total or average	1,170,000	11,400,000	9.73	1,160,000	11,300,000	9.66

W Withheld to avoid disclosing company proprietary data; included with "Other."

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Estimated quantities for the prior year have been recalculated.

[3] A significant amount of sold or used material was shipped in from other States.

[4] Includes Tutuila Island and dependencies.

[5] Withheld to avoid disclosing company proprietary data; included in "Grand total or average."

TABLE 5A

CRUSHED STONE SOLD OR USED IN THE UNITED STATES, BY SIZE OF OPERATION[1, 2]

Size range (metric tons)	2009[3] Number of operations	2009[3] Percentage of total	2009[3] Quantity (thousand metric tons)	2009[3] Percentage of total	2010 Number of operations	2010 Percentage of total	2010 Quantity (thousand metric tons)	2010 Percentage of total
Less than 25,000	636	16.5	5,310	0.5	642	17.1	5,120	0.4
25,000 to 49,999	342	8.9	11,400	1.0	366	9.7	12,400	1.1
50,000 to 99,999	531	13.8	35,100	3.0	494	13.1	33,000	2.9
100,000 to 199,999	620	16.1	81,700	7.0	579	15.4	77,100	6.7
200,000 to 299,999	428	11.1	97,100	8.4	401	10.7	90,400	7.8
300,000 to 399,999	306	7.9	96,400	8.3	300	8.0	94,300	8.2
400,000 to 499,999	250	6.5	102,000	8.8	232	6.2	94,200	8.1
500,000 to 599,999	163	4.2	80,400	6.9	158	4.2	78,400	6.8
600,000 to 699,999	127	3.3	74,400	6.4	134	3.6	79,100	6.8
700,000 to 799,999	85	2.2	57,400	4.9	84	2.2	56,800	4.9
800,000 to 899,999	69	1.8	52,900	4.6	55	1.5	42,500	3.7
900,000 to 999,999	43	1.1	37,000	3.2	44	1.2	37,600	3.3
1,000,000 to 1,499,999	145	3.8	158,000	13.6	151	4.0	167,000	14.4
1,500,000 to 1,999,999	45	1.2	68,600	5.9	54	1.4	83,700	7.2
2,000,000 to 2,499,999	30	0.8	61,100	5.3	27	0.7	54,400	4.7
2,500,000 to 4,999,999	34	0.9	101,000	8.7	37	1.0	112,000	9.7
5,000,000 and more	7	0.2	41,100	3.5	6	0.2	38,500	3.3
Total	3,860	100	1,160,000	100	3,760	100	1,160,000	100

[1] Data are rounded to no more than three significant digits except "Number of operations"; may not add to totals shown.

[2] Does not include recycle plants.

[3] Estimated quantities for the prior year have been recalculated.

TABLE 5B

CRUSHED STONE SOLD OR USED IN THE UNITED STATES IN 2010, BY REGION AND SIZE OF OPERATION[1, 2]

	Northeast				Midwest			
Size range (metric tons)	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total
Less than 25,000	82	14.1	773	0.5	162	15.0	1,550	0.5
25,000 to 49,999	67	11.5	2,170	1.3	98	9.1	3,250	1.0
50,000 to 99,999	68	11.7	4,560	2.7	152	14.1	10,000	3.1
100,000 to 199,999	99	17.0	13,300	8.0	174	16.1	23,000	7.0
200,000 to 299,999	62	10.7	13,800	8.3	117	10.8	26,000	7.9
300,000 to 399,999	44	7.6	13,700	8.3	100	9.3	31,100	9.5
400,000 to 499,999	45	7.7	18,100	10.9	73	6.8	29,800	9.1
500,000 to 599,999	20	3.4	9,900	6.0	47	4.4	23,400	7.1
600,000 to 699,999	29	5.0	17,400	10.5	39	3.6	23,000	7.0
700,000 to 799,999	15	2.6	10,200	6.1	20	1.9	13,500	4.1
800,000 to 899,999	4	0.7	3,130	1.9	14	1.3	10,800	3.3
900,000 to 999,999	7	1.2	6,020	3.6	12	1.1	10,300	3.1
1,000,000 to 1,499,999	28	4.8	31,100	18.8	39	3.6	44,100	13.4
1,500,000 to 1,999,999	6	1.0	8,870	5.3	14	1.3	21,600	6.6
2,000,000 to 2,499,999	5	0.9	10,100	6.1	6	0.6	12,200	3.7
2,500,000 to 4,999,999	1	0.2	2,670	1.6	11	1.0	32,500	9.9
5,000,000 and more	--	--	--	--	2	0.2	11,600	3.5
Total	582	100	166,000	100	1,080	100	328,000	100

	South				West			
	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total	Number of operations	Percentage of total	Quantity (thousand metric tons)	Percentage of total
Less than 25,000	114	8.7	881	0.2	284	35.6	1,920	1.6
25,000 to 49,999	82	6.3	2,890	0.5	119	14.9	4,040	3.5
50,000 to 99,999	150	11.5	10,300	1.9	124	15.6	8,180	7.0
100,000 to 199,999	182	13.9	24,800	4.5	124	15.6	16,000	13.7
200,000 to 299,999	174	13.3	40,100	7.4	48	6.0	10,500	9.0
300,000 to 399,999	135	10.3	42,800	7.8	21	2.6	6,780	5.8
400,000 to 499,999	100	7.7	40,600	7.4	14	1.8	5,720	4.9
500,000 to 599,999	77	5.9	38,100	7.0	14	1.8	6,990	6.0
600,000 to 699,999	58	4.4	34,100	6.2	8	1.0	4,600	3.9
700,000 to 799,999	38	2.9	25,700	4.7	11	1.4	7,410	6.4
800,000 to 899,999	36	2.8	27,800	5.1	1	0.1	739	0.6
900,000 to 999,999	22	1.7	18,800	3.4	3	0.4	2,490	2.1
1,000,000 to 1,499,999	73	5.6	79,300	14.5	11	1.4	12,000	10.3
1,500,000 to 1,999,999	26	2.0	40,900	7.5	8	1.0	12,300	10.6
2,000,000 to 2,499,999	12	0.9	24,400	4.5	4	0.5	7,680	6.6
2,500,000 to 4,999,999	22	1.7	67,300	12.3	3	0.4	9,360	8.0
5,000,000 and more	4	0.3	26,800	4.9	--	--	--	--
Total	1,310	100	545,000	100	797	100	117,000	100

-- Zero.

[1] Data are rounded to no more than three significant digits except "Number of operations"; may not add to totals shown.

[2] Does not include recycle plants.

TABLE 6
LIMESTONE, DOLOMITE, CALCAREOUS MARL, AND MARBLE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2010, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

State	Limestone		Dolomite		Calcareous marl		Marble	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	29,000	270,000	1,070	9,670	--	--	1,810	17,500
Alaska	--	--	--	--	--	--	--	--
Arizona	3,320[3]	34,300	--	--	--	--	(4)	--
Arkansas	11,300	81,000	(5)	--	--	--	--	--
California	13,400[3]	119,000	226	2,100	--	--	--	--
Colorado	407	4,050	(5)	--	--	--	(4)	--
Connecticut	1,180[3]	22,600	(5)	--	--	--	(4)	--
Delaware	(4)	--	--	--	--	--	--	--
Florida	39,600[3]	512,000	(5)	--	--	--	--	--
Georgia	4,610	52,400	--	--	--	--	1,060	24,400
Hawaii	(4)	--	--	--	--	--	--	--
Idaho	250	3,670	--	--	--	--	--	--
Illinois	43,100[3]	381,000	9,550	91,600	--	--	--	--
Indiana	40,100[3]	260,000	4,050	29,600	--	--	--	--
Iowa	31,800[3]	291,000	(5)	--	--	--	--	--
Kansas	15,800	135,000	--	--	--	--	--	--
Kentucky	49,100	424,000	--	--	--	--	--	--
Louisiana	(4)	--	--	--	--	--	--	--
Maine	1,620	12,200	--	--	--	--	--	--
Maryland	12,400[3]	125,000	--	--	--	--	(4)	--
Massachusetts	792[3]	15,900	--	--	--	--	--	--
Michigan	16,300[3]	93,800	4,670	25,000	(4)	--	--	--
Minnesota	2,590[3]	29,800	1,590	22,700	--	--	--	--
Mississippi	2,710	63,200	--	--	--	--	--	--
Missouri	65,400[3]	513,000	2,500	19,500	--	--	(4)	--
Montana	1,610	17,200	--	--	--	--	--	--
Nebraska	6,680	69,200	--	--	--	--	--	--
Nevada	2,250	28,600	(5)	--	--	--	--	--
New Hampshire	(4)	--	--	--	--	--	--	--
New Jersey	(4)	--	--	--	--	--	--	--
New Mexico	2,780	21,700	--	--	--	--	--	--
New York	19,900[3]	222,000	7,240	70,400	--	--	94	1,030
North Carolina	4,210	61,000	(5)	--	--	--	--	--
North Dakota	--	--	--	--	--	--	--	--
Ohio	44,200[3]	370,000	2,300	19,100	--	--	--	--
Oklahoma	33,900[3]	301,000	(5)	--	--	--	--	--
Oregon	(4)	--	(4)	--	--	--	--	--
Pennsylvania	47,000[3]	526,000	10,700	110,000	--	--	(4)	--
Rhode Island	--	--	--	--	--	--	--	--
South Carolina	2,530	24,900	--	--	2,720	21,400	--	--
South Dakota	2,690	15,700	--	--	--	--	(4)	--
Tennessee	39,600[3]	448,000	(5)	--	--	--	--	--
Texas	103,000	725,000	--	--	--	--	100	2,990
Utah	4,230	32,400	(5)	--	--	--	--	--
Vermont	2,000[3]	19,500	(5)	--	--	--	(4)	--
Virginia	15,700[3]	203,000	(5)	--	--	--	(4)	--
Washington	967[3]	12,400	198	3,220	--	--	(4)	--
West Virginia	13,600	129,000	--	--	--	--	--	--

See footnotes at end of table.

TABLE 6—Continued

LIMESTONE, DOLOMITE, CALCAREOUS MARL, AND MARBLE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2010, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

State	Limestone		Dolomite		Calcareous marl		Marble	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Wisconsin	19,300 [3]	111,000	165	882	--	--	(4)	--
Wyoming	2,940 [3]	19,000	--	--	--	--	--	--
Total	754,000	6,800,000	44,300	404,000	2,720	21,400	3,070	45,900

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Totals may not match totals shown in table 2 because of concealments.

[3] Includes limestone-dolomite reported with no distinction between the two kinds of stone.

[4] Concealed to avoid disclosing company proprietary data; included with "Miscellaneous stone."

[5] Concealed to avoid disclosing company proprietary data; included with "Limestone."

TABLE 7
GRANITE, TRAPROCK, SANDSTONE AND QUARTZITE, AND SLATE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2010, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

State	Granite		Traprock		Sandstone and quartzite[3]		Slate	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	1,860	18,200	--	--	920	8,960	(4)	--
Alaska	203	2,680	261	2,500	--	--	--	--
Arizona	2,130	22,000	(4)	--	528	5,350	--	--
Arkansas	7,570	61,000	--	--	10,600	84,000	(4)	--
California	8,730	85,100	4,760	55,800	1,030	9,270	(4)	--
Colorado	4,780	38,500	(4)	--	1,330	10,000	--	--
Connecticut	526	5,500	4,450	50,300	--	--	--	--
Delaware	--	--	(4)	--	--	--	--	--
Florida	(4)	--	--	--	(4)	--	--	--
Georgia	37,000	387,000	--	--	203	2,270	(4)	--
Hawaii	--	--	4,180	81,000	--	--	--	--
Idaho	251	1,180	1,720	8,210	(4)	--	--	--
Illinois	--	--	--	--	(4)	--	--	--
Indiana	--	--	--	--	--	--	--	--
Iowa	--	--	--	--	--	--	--	--
Kansas	--	--	--	--	934	7,720	--	--
Kentucky	--	--	--	--	--	--	--	--
Louisiana	--	--	--	--	(4)	--	--	--
Maine	1,240	12,200	(4)	--	279	2,480	--	--
Maryland	4,600	44,900	(4)	--	96	2,340	--	--
Massachusetts	3,490	38,000	4,660	49,400	--	--	--	--
Michigan	--	--	(4)	--	--	--	--	--
Minnesota	2,810	33,700	--	--	(4)	--	--	--
Mississippi	--	--	--	--	--	--	--	--
Missouri	899	52,900	(4)	--	--	--	--	--
Montana	(4)	--	(4)	--	9	130	--	--
Nebraska	--	--	--	--	(4)	--	--	--
Nevada	107	1,120	(4)	--	(4)	--	--	--
New Hampshire	2,190	19,200	1,550	14,500	(4)	--	--	--
New Jersey	5,160	47,100	9,070	70,600	--	--	--	--
New Mexico	--	--	--	--	(4)	--	--	--
New York	1,040	15,000	(4)	--	1,690	20,400	(4)	--
North Carolina	28,300	413,000	5,330	77,200	--	--	(4)	--
North Dakota	--	--	--	--	(4)	--	--	--
Ohio	--	--	--	--	315	2,750	--	--
Oklahoma	2,580	21,900	--	--	946	8,130	--	--
Oregon	362	2,460	7,820	64,300	(4)	--	--	--
Pennsylvania	2,740	30,100	4,860	183,000	11,500	114,000	1,170	11,800
Rhode Island	595	6,890	(4)	--	--	--	--	--
South Carolina	13,400	163,000	--	--	--	--	--	--
South Dakota	(4)	--	--	--	2,010	15,300	(4)	--
Tennessee	(4)	--	--	--	812	10,100	--	--
Texas	(4)	--	(4)	--	2,960	17,300	--	--
Utah	--	--	--	--	242	3,150	--	--
Vermont	(4)	--	(4)	--	1,020	12,100	249	2,640
Virginia	18,400	269,000	7,460	104,000	1,280	18,600	(4)	--
Washington	682	6,730	6,100	55,000	726	14,600	--	--

See footnotes at end of table.

TABLE 7—Continued
GRANITE, TRAPROCK, SANDSTONE AND QUARTZITE, AND SLATE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2010, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

State	Granite		Traprock		Sandstone and quartzite[3]		Slate	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
West Virginia	--	--	--	--	1,070	12,400	--	--
Wisconsin	1,460	8,410	1,510	9,020	(4)	--	--	--
Wyoming	(4)	--	--	--	--	--	--	--
Total	153,000	1,810,000	63,700	825,000	40,500	382,000	1,420	14,400

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Totals may not match totals shown in table 2 because of concealments.

[3] Includes sandstone-quartzite reported with no distinction between the two kinds of stone.

[4] Concealed to avoid disclosing company proprietary data; included with "Miscellaneous stone."

TABLE 8
SHELL, VOLCANIC CINDER AND SCORIA, AND MISCELLANEOUS STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2010, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

State	Shell		Volcanic cinder and scoria		Miscellaneous stone	
	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	--	--	--	--	694	6,760
Alaska	(3)	--	--	--	1,040	17,400
Arizona	--	--	123	759	2,170	18,000
Arkansas	--	--	--	--	1,540	11,800
California	(3)	--	313	3,500	3,330	38,300
Colorado	--	--	(3)	--	799	5,820
Connecticut	--	--	--	--	1,100	14,200
Delaware	--	--	--	--	W	W
Florida	1,670	20,900	--	--	1,560	14,700
Georgia	--	--	--	--	7	168
Hawaii	--	--	103	1,760	463	9,210
Idaho	--	--	(3)	--	1,810	10,900
Illinois	--	--	--	--	515	4,120
Indiana	--	--	--	--	138	1,020
Iowa	--	--	--	--	36	340
Kansas	--	--	--	--	--	--
Kentucky	--	--	--	--	73	688
Louisiana	--	--	--	--	W	W
Maine	--	--	--	--	291	3,300
Maryland	--	--	--	--	4,600	48,600
Massachusetts	--	--	--	--	1,500	16,200
Michigan	--	--	--	--	986	2,780
Minnesota	--	--	--	--	372	4,050
Mississippi	--	--	--	--	200	2,320
Missouri	--	--	--	--	1,380	9,640
Montana	--	--	(3)	--	402	3,960
Nebraska	--	--	--	--	79	822
Nevada	--	--	(3)	--	4,620	51,000
New Hampshire	--	--	--	--	575	5,780
New Jersey	--	--	--	--	126	1,070
New Mexico	--	--	226	1,520	1,270	10,900
New York	--	--	--	--	3,100	38,000
North Carolina	--	--	--	--	2,760	40,000
North Dakota	--	--	86	987	749	2,790
Ohio	--	--	--	--	338	2,730
Oklahoma	--	--	--	--	1,620	12,800
Oregon	--	--	18	71	8,070	55,000
Pennsylvania	--	--	--	--	7,600	75,500
Rhode Island	--	--	--	--	844	8,880
South Carolina	--	--	--	--	486	6,030
South Dakota	--	--	--	--	188	1,280
Tennessee	--	--	--	--	499	5,720
Texas	--	--	--	--	8,170	61,400
Utah	--	--	(3)	--	1,370	8,200
Vermont	--	--	--	--	2,820	29,800
Virginia	--	--	--	--	1,320	18,100
Washington	--	--	(3)	--	6,110	41,300
West Virginia	--	--	--	--	--	--
Wisconsin	--	--	--	--	167	998

See footnotes at end of table.

TABLE 8—Continued
SHELL, VOLCANIC CINDER AND SCORIA, AND MISCELLANEOUS STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2010, BY STATE[1, 2]

(Thousand metric tons and thousand dollars)

State	Shell		Volcanic cinder and scoria		Miscellaneous stone	
	Quantity	Value	Quantity	Value	Quantity	Value
Wyoming	--	--	1,140	5,450	4,830	15,800
Other	--	--	--	--	6,730	102,000
Total	1,670	20,900	2,010	14,000	89,400	840,000

W Withheld to avoid disclosing company proprietary data; included with "Other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Totals may not match totals shown in table 2 because of concealments.

[3] Concealed to avoid disclosing company proprietary data; included with "Miscellaneous stone."

TABLE 9
CRUSHED STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2009[2]			2010		
	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Construction:						
Coarse aggregate (+1½ inch):						
Macadam	1,650	$17,900	$10.83	1,270	$12,700	$10.01
Riprap and jetty stone	9,600	100,000	10.44	10,000	114,000	11.33
Filter stone	3,600	36,700	10.22	3,540	36,200	10.24
Other coarse aggregate	17,400	196,000	11.22	21,300	221,000	10.34
Coarse aggregate, graded:						
Concrete aggregate, coarse	29,800	292,000	9.82	27,000	258,000	9.58
Bituminous aggregate, coarse	19,200	189,000	9.82	26,300	260,000	9.87
Bituminous surface-treatment aggregate	6,490	80,300	12.38	5,880	68,900	11.72
Railroad ballast	9,540	88,700	9.30	5,750	55,400	9.63
Other graded coarse aggregate	94,700	1,130,000	11.89	93,100	1,130,000	12.15
Fine aggregate (-⅜ inch):						
Stone sand, concrete	4,560	54,900	12.05	3,560	39,600	11.14
Stone sand, bituminous mix or seal	6,310	63,800	10.12	6,410	64,700	10.09
Screening, undesignated	9,420	85,900	9.11	10,900	99,100	9.11
Other fine aggregate	44,300	514,000	11.62	34,600	365,000	10.55
Coarse and fine aggregates:						
Graded road base or subbase	56,300	411,000	7.30	58,700	446,000	7.59
Unpaved road surfacing	12,200	94,000	7.74	14,400	116,000	8.05
Terrazzo and exposed aggregate	328	8,040	24.49	266	10,700	40.27
Crusher run or fill or waste	15,000	113,000	7.52	16,800	123,000	7.34
Roofing granules	2,590	313,000	121.23	648	54,600	84.28
Other coarse and fine aggregates	75,900	728,000	9.60	82,800	792,000	9.57
Other construction materials	6,510	50,200	7.70	5,250	54,900	10.46
Agricultural:						
Agricultural limestone	7,810	74,500	9.53	10,700	87,700	8.19
Poultry grit and mineral food	970	19,900	20.55	1,330	26,700	20.12
Other agricultural uses	589	21,900	37.13	690	23,200	33.62
Chemical and metallurgical:						
Cement manufacture	51,200	270,000	5.28	52,600	298,000	5.66
Lime manufacture	11,700	101,000	8.60	16,400	194,000	11.81
Dead-burned dolomite manufacture	--	--	--	383	2,050	5.35
Flux stone	2,490	15,300	6.14	2,510	18,600	7.41
Chemical stone	227	2,040	8.99	137	1,290	9.45
Glass manufacture	896	22,000	24.59	821	13,800	16.84
Sulfur oxide removal	5,690	45,800	8.05	7,670	72,000	9.38
Special:						
Mine dusting or acid water treatment	150	7,080	47.35	727	19,600	27.01
Asphalt fillers or extenders	687	8,320	12.10	1,400	14,800	10.61
Whiting or whiting substitute	178	3,000	16.90	235	4,450	18.91
Other fillers or extenders	2,220	35,500	15.99	2,600	59,300	22.76
Other miscellaneous uses and specified uses not listed	716	22,300	31.18	5,250	52,400	9.99
Unspecified:[3]						
Reported	307,000	3,010,000	9.83	310,000	3,020,000	9.75
Estimated	344,000	3,100,000	8.99	314,000	2,940,000	9.38
Total or average	1,160,000	11,300,000	9.74	1,160,000	11,200,000	9.67

-- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Estimated quantities for the prior year have been recalculated.

[3] Reported and estimated production without a breakdown by end use.

TABLE 10

LIMESTONE AND DOLOMITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2010, BY USE[1, 2]

(Thousand metric tons and thousand dollars)

Use	Limestone[3]			Dolomite		
	Quantity	Value	Unit value	Quantity	Value	Unit value
Construction:						
Coarse aggregate (+1½ inch):						
Macadam	1,010	9,860	$9.75	9	80	$8.89
Riprap and jetty stone	7,260	75,800	10.44	210	2,950	14.08
Filter stone	2,590	24,400	9.41	32	293	9.09
Other coarse aggregate	16,000	152,000	9.50	827	9,070	10.97
Coarse aggregate, graded:						
Concrete aggregate, coarse	16,500	158,000	9.62	2,820	21,200	7.52
Bituminous aggregate, coarse	15,600	159,000	10.20	1,670	15,500	9.26
Bituminous surface-treatment aggregate	2,730	29,100	10.64	1,230	13,400	10.88
Railroad ballast	1,350	10,400	7.65	107	897	8.35
Other graded coarse aggregate	63,600	698,000	10.98	3,540	43,100	12.20
Fine aggregate (-⅜ inch):						
Stone sand, concrete	1,390	13,600	9.77	137	1,350	9.81
Stone sand, bituminous mix or seal	3,250	32,500	9.98	915	9,500	10.38
Screening, undesignated	5,460	45,500	8.34	566	4,790	8.46
Other fine aggregate	20,000	208,000	10.39	2,490	23,400	9.43
Coarse and fine aggregates:						
Graded road base or subbase	37,800	275,000	7.28	2,210	18,700	8.47
Unpaved road surfacing	9,190	76,200	8.28	1,200	12,000	9.96
Terrazzo and exposed aggregate	93	5,190	55.91	36	1,900	52.36
Crusher run or fill or waste	9,290	63,500	6.83	2,140	16,900	7.90
Roofing granules	304	5,090	16.73			
Other coarse and fine aggregates	51,300	458,000	8.93	4,100	32,900	8.02
Other construction materials	2,460	24,700	10.06	192	1,250	6.50
Agricultural:						
Agricultural limestone	9,600	79,400	8.27	990	7,440	7.51
Poultry grit and mineral food	1,290	22,800	17.67	1	16	10.44
Other agricultural uses	548	20,400	37.21	10	901	94.33
Chemical and metallurgical:						
Cement manufacture	50,900	288,000	5.65	57	37	0.65
Lime manufacture	16,300	192,000	11.79	--	--	--
Dead-burned dolomite manufacture	3	28	10	380	2,020	5
Flux stone	917	10,000	10.93	1,580	8,510	5.37
Chemical stone	136	1,280	9.37	--	--	--
Glass manufacture	477	7,110	14.88	--	--	--
Sulfur oxide removal	7,670	72,000	9.38	--	--	--
Special:						
Mine dusting or acid water treatment	677	17,900	26.48	--	--	--
Asphalt fillers or extenders	916	10,200	11.16	--	--	--
Whiting or whiting substitute	171	4,080	23.83	--	--	--
Other fillers or extenders	1,910	40,400	21.11	20	419	21.33
Other miscellaneous uses and specified uses not listed	600	8,380	13.98	262	3,920	14.96
Unspecified:[4]						
Reported	183,000	1,690,000	9.20	10,800	103,000	9.49
Estimated	211,000	1,820,000	8.60	5,720	48,400	8.47
Total	754,000	6,800,000	9.02	44,300	404,000	9.12

-- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Totals may not match totals shown in table 2 because of concealments.

[3] Includes a minor amount of limestone-dolomite reported without a distinction between the two.

[4] Reported and estimated production without a breakdown by end use.

TABLE 11

LIMESTONE AND DOLOMITE SOLD OR USED BY PRODUCERS IN 2010, BY STATE AND USE[1]

(Thousand metric tons and thousand dollars)

State	Concrete aggregate		Bituminous aggregate		Roadstone and coverings		Riprap and railroad ballast		Other construction uses	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	1,790	15,600	7,260	70,600	2,690	27,500	461	4,630	4,470	48,900
Alaska	--	--	--	--	--	--	--	--	--	--
Arizona	--	--	--	--	--	--	--	--	W	W
Arkansas	289	2,410	395	3,920	1,130	9,610	101	1,060	1,770	12,700
California	W	W	101	1,640	108	1,160	82	1,120	310	2,370
Colorado	--	--	--	--	--	--	11	153	--	--
Connecticut	10	155	21	337	23	203	W	W	W	W
Delaware	--	--	--	--	--	--	--	--	--	--
Florida	4,230	67,800	4,090	85,500	3,910	28,400	66	1,230	5,600	55,100
Georgia	W	W	W	W	W	W	--	--	W	W
Hawaii	--	--	--	--	--	--	--	--	--	--
Idaho	--	--	--	--	45	185	--	--	--	--
Illinois	2,450	19,500	8,810	97,100	4,420	31,900	544	6,450	4,420	31,100
Indiana	4,030	26,300	8,410	59,000	3,370	22,000	607	4,830	3,360	21,100
Iowa	1,010	11,200	904	12,000	6,810	63,800	310	5,590	1,510	10,100
Kansas	514	5,160	376	5,490	725	4,410	4	76	705	3,990
Kentucky	2,510	23,300	8,220	76,700	6,020	46,300	711	7,020	4,830	40,400
Louisiana	--	--	--	--	--	--	--	--	--	--
Maine	73	380	--	--	23	87	--	--	--	--
Maryland	2,800	29,500	2,230	21,800	246	2,110	21	282	847	6,240
Massachusetts	--	--	--	--	109	1,450	--	--	27	233
Michigan	3,250	16,200	390	2,210	1,710	9,130	117	1,280	354	1,710
Minnesota	W	W	638	11,600	422	4,200	44	859	450	4,170
Mississippi[2]	W	W	W	W	W	W	--	--	W	W
Missouri	1,930	18,500	2,260	20,200	6,150	43,600	2,550	20,400	1,730	11,200
Montana	--	--	--	--	W	W	W	W	W	W
Nebraska	W	W	W	W	W	W	W	W	W	W
Nevada	--	--	--	--	--	--	--	--	--	--
New Hampshire	--	--	--	--	--	--	--	--	--	--
New Jersey	--	--	--	--	--	--	--	--	--	--
New Mexico	128	1,690	29	284	150	1,090	37	681	86	515
New York	3,320	36,500	3,350	48,100	1,010	11,000	224	2,990	5,560	52,200
North Carolina	W	W	W	W	W	W	W	W	W	W
North Dakota	--	--	--	--	--	--	--	--	--	--
Ohio	2,210	18,700	8,730	79,600	8,210	69,000	376	3,730	3,450	24,700
Oklahoma	359	4,130	3,540	28,500	1,120	11,900	133	1,830	960	9,010
Oregon	--	--	--	--	--	--	--	--	--	--
Pennsylvania	3,180	31,400	8,690	77,800	5,810	55,700	794	8,680	7,540	64,400
Rhode Island	--	--	--	--	--	--	--	--	--	--
South Carolina	W	W	W	W	W	W	5	52	238	1,910
South Dakota	--	--	--	--	--	--	--	--	W	W
Tennessee	2,080	27,100	9,930	130,000	3,250	29,900	820	6,770	8,150	77,900
Texas	3,260	24,400	7,390	87,400	5,440	27,100	475	4,070	14,600	119,000
Utah	--	--	--	--	--	--	--	--	W	W
Vermont	W	W	W	W	W	W	W	W	355	2,990
Virginia	1,550	19,100	2,190	25,800	1,450	15,200	214	2,830	1,760	17,700
Washington	W	W	W	W	138	658	--	--	W	W
West Virginia	362	3,850	2,600	24,800	828	8,790	76	1,280	1,620	16,800
Wisconsin	328	2,050	1,270	9,180	1,450	7,590	70	797	2,120	11,000
Wyoming	W	W	W	W	W	W	--	--	W	W
Total	41,600	405,000	91,800	979,000	66,800	534,000	8,860	88,700	76,800	648,000
Total withheld	1,670	21,000	1,710	31,600	1,480	19,200	74	1,310	1,920	40,400
Grand total	43,300	426,000	93,500	1,010,000	68,300	553,000	8,930	90,000	78,800	688,000

See footnotes at end of table.

TABLE 11—Continued

LIMESTONE AND DOLOMITE SOLD OR USED BY PRODUCERS IN 2010, BY STATE AND USE[1]

(Thousand metric tons and thousand dollars)

	Cement manufacture		Agricultural uses		Lime manufacture		Other uses		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	367	3,540	W	W	10,100	85,500	30,100	280,000
Alaska	--	--	--	--	--	--	--	--	--	--
Arizona	W	W	W	W	--	--	1,530	15,700	3,320	34,300
Arkansas	W	W	185	1,930	W	W	5,480	41,400	11,300	81,000
California	6,660	18,400	327	11,200	--	--	5,980	84,900	13,600	121,000
Colorado	--	--	--	--	32	237	364	3,660	407	4,050
Connecticut	--	--	9	92	--	--	705	8,010	1,180	22,600
Delaware	--	--	--	--	--	--	--	--	--	--
Florida	W	W	631	4,060	--	--	20,700	267,000	39,600	512,000
Georgia	W	W	68	600	--	--	2,580	30,500	4,610	52,400
Hawaii	--	--	--	--	--	--	--	--	--	--
Idaho	--	--	W	W	--	--	W	W	250	3,670
Illinois	W	W	1,910	10,800	W	W	29,200	268,000	52,600	473,000
Indiana	3,240	12,500	1,860	11,700	W	W	19,300	132,000	44,200	290,000
Iowa	490	1,080	900	6,790	W	W	19,500	177,000	31,800	291,000
Kansas	W	W	63	227	--	--	11,200	97,000	15,800	135,000
Kentucky	--	--	427	2,360	W	W	21,800	189,000	49,100	424,000
Louisiana	--	--	--	--	--	--	--	--	--	--
Maine	W	W	--	--	--	--	962	9,180	1,620	12,200
Maryland	--	--	--	--	--	--	6,250	64,800	12,400	125,000
Massachusetts	--	--	61	780	5	66	590	13,400	792	15,900
Michigan	--	--	231	1,840	--	--	14,900	86,400	20,900	119,000
Minnesota	--	--	120	1,230	--	--	2,310	28,000	4,170	52,500
Mississippi[2]	--	--	97	2,900	--	--	593	11,700	2,710	63,200
Missouri	7,780	48,800	841	4,380	1,690	11,100	43,000	354,000	67,900	532,000
Montana	W	W	W	W	W	W	779	9,650	1,610	17,200
Nebraska	W	W	253	4,440	--	--	4,230	43,800	6,680	69,200
Nevada	W	W	W	W	W	W	--	--	2,250	28,600
New Hampshire	--	--	--	--	--	--	--	--	--	--
New Jersey	--	--	--	--	--	--	--	--	--	--
New Mexico	--	--	--	--	--	--	2,350	17,400	2,780	21,700
New York	1,090	11,600	163	1,940	--	--	12,400	128,000	27,100	293,000
North Carolina	--	--	2	86	--	--	3,960	57,700	4,210	61,000
North Dakota	--	--	--	--	--	--	--	--	--	--
Ohio	W	W	964	9,250	--	--	21,200	175,000	46,500	389,000
Oklahoma	W	W	132	982	W	W	26,300	239,000	33,900	301,000
Oregon	--	--	--	--	--	--	--	--	--	--
Pennsylvania	3,070	34,700	972	13,400	1,670	64,500	26,000	286,000	57,700	636,000
Rhode Island	--	--	--	--	--	--	--	--	--	--
South Carolina	--	--	--	--	--	--	1,630	16,400	2,530	24,900
South Dakota	W	W	--	--	--	--	1,940	13,400	2,690	15,700
Tennessee	W	W	214	2,960	W	W	13,700	145,000	39,600	448,000
Texas	11,100	40,100	469	5,420	W	W	59,000	412,000	103,000	725,000
Utah	1,610	14,100	W	W	W	W	1,460	11,500	4,230	32,400
Vermont	--	--	W	W	--	--	1,460	15,100	2,000	19,500
Virginia	--	--	553	11,100	--	--	7,940	111,000	15,700	203,000
Washington	2	20	--	--	W	W	803	11,000	1,170	15,700
West Virginia	W	W	W	W	--	--	6,890	67,400	13,600	129,000
Wisconsin	--	--	429	3,420	--	--	13,800	77,800	19,500	112,000

See footnotes at end of table.

TABLE 11—Continued

LIMESTONE AND DOLOMITE SOLD OR USED BY PRODUCERS IN 2010, BY STATE AND USE[1]

(Thousand metric tons and thousand dollars)

	Cement manufacture		Agricultural uses		Lime manufacture		Other uses		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Wyoming	359	2,040	--	--	--	--	2,370	15,100	2,940	19,000
Total	35,400	184,000	12,200	117,000	3,400	75,900	425,000	3,820,000	798,000	7,200,000
Total withheld	15,500	104,000	194	13,600	13,300	119,000	163	2,150	XX	XX
Grand total	50,900	288,000	12,400	131,000	16,700	195,000	425,000	3,820,000	798,000	7,200,000

W Withheld to avoid disclosing company proprietary data; included in "Total" or "Total withheld." XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] A significant amount of sold or used material was shipped in from other States.

TABLE 12

GRANITE, TRAPROCK, SANDSTONE AND QUARTZITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2010, BY USE[1, 2]

(Thousand metric tons and thousand dollars)

Use	Granite		Traprock		Sandstone and quartzite[3]	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction:						
Coarse aggregate (+1½ inch):						
Macadam	--	--	137	1,190	70	924
Riprap and jetty stone	1,550	19,400	273	4,620	308	4,410
Filter stone	371	4,650	278	3,470	137	1,570
Other coarse aggregate	1,680	30,400	427	4,920	411	3,270
Coarse aggregate, graded:						
Concrete aggregate, coarse	3,490	33,300	1,240	11,200	717	7,530
Bituminous aggregate, coarse	3,280	33,100	1,240	11,600	602	6,410
Bituminous surface-treatment aggregate	798	11,400	200	1,790	293	3,720
Railroad ballast	3,390	33,300	365	3,700	41	595
Other graded coarse aggregate	17,400	271,000	2,990	41,200	989	10,500
Fine aggregate (-⅜ inch):						
Stone sand, concrete	211	2,480	197	5,490	673	7,050
Stone sand, bituminous mix or seal	777	6,970	731	8,230	211	2,630
Screening, undesignated	3,060	31,300	839	10,200	415	2,960
Other fine aggregate	6,330	72,800	2,100	23,100	766	8,290
Coarse and fine aggregates:						
Graded road base or subbase	5,460	52,600	5,160	42,100	2,230	18,800
Unpaved road surfacing	321	3,240	559	3,810	275	2,240
Terrazzo and exposed aggregate	9	87	9	80	20	250
Crusher run or fill or waste	2,050	16,500	761	5,840	794	5,530
Roofing granules	322	49,000	10	50	9	341
Other coarse and fine aggregates	14,200	153,000	6,860	75,400	1,170	10,400
Other construction materials	211	1,560	931	13,900	391	4,940
Agricultural:						
Agricultural limestone	--	--	--	--	--	--
Poultry grit and mineral food	--	--	--	--	--	--
Other agricultural uses	42	538	2	23	5	80
Chemical and metallurgical:	--	--	--	--	--	--
Cement manufacture	--	--	--	--	135	1,620
Lime manufacture	77	809	--	--	--	--
Dead-burned dolomite manufacture	--	--	--	--	--	--
Flux stone	--	--	--	--	10	83
Chemical stone	--	--	--	--	--	--
Glass manufacture	--	--	--	--	344	6,730
Sulfur oxide removal	--	--	--	--	--	--
Special:						
Mine dusting or acid water treatment	--	--	--	--	--	--
Asphalt fillers or extenders	294	3,100	--	--	--	--
Whiting or whiting substitute	--	--	--	--	--	--
Other fillers or extenders	--	--	--	--	--	--
Other miscellaneous uses and specified uses not listed	56	561	35	373	2,620	22,400
Unspecified:[4]						
Reported	66,100	744,000	20,000	235,000	9,870	85,800
Estimated	21,600	232,000	18,400	318,000	17,000	162,000
Total	153,000	1,810,000	63,700	825,000	40,500	382,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Totals may not match totals shown in table 2 because of concealments.

[3] Includes sandstone-quartzite reported with no distinction between the two kinds of stone.

[4] Reported and estimated production without a breakdown by end use.

TABLE 13
MARBLE, VOLCANIC CINDER AND SCORIA, AND MISCELLANEOUS STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES IN 2010, BY USE[1, 2]

(Thousand metric tons and thousand dollars)

Use	Marble		Volcanic cinder and scoria		Miscellaneous stone	
	Quantity	Value	Quantity	Value	Quantity	Value
Construction:						
Coarse aggregate (+1½ inch):						
Macadam	--	--	--	--	40	632
Riprap and jetty stone	--	--	1	18	413	6,200
Filter stone	--	--	--	--	129	1,850
Other coarse aggregate	--	--	8	60	1,930	20,400
Coarse aggregate, graded:						
Concrete aggregate, coarse	24	171	--	--	1,970	21,800
Bituminous aggregate, coarse	--	--	--	--	3,910	33,800
Bituminous surface-treatment aggregate	--	--	--	--	626	9,550
Railroad ballast	--	--	--	--	495	6,530
Other graded coarse aggregate	--	--	49	488	4,140	59,300
Fine aggregate (-⅜ inch):						
Stone sand, concrete	64	627	--	--	882	9,060
Stone sand, bituminous mix or seal	--	--	--	--	523	4,880
Screening, undesignated	--	--	2	49	516	4,170
Other fine aggregate	--	--	1	6	2,550	25,900
Coarse and fine aggregates:						
Graded road base or subbase	--	--	76	775	5,230	34,100
Unpaved road surfacing	--	--	87	563	2,710	17,200
Terrazzo and exposed aggregate	12	2,190	2	46	85	957
Crusher run or fill or waste	--	--	85	378	1,310	12,100
Roofing granules	--	--	--	--	4	159
Other coarse and fine aggregates	--	--	20	165	5,110	62,600
Other construction materials	--	--	66	987	920	6,720
Agricultural:						
Agricultural limestone	--	--	--	--	110	887
Poultry grit and mineral food	--	--	--	--	34	3,860
Other agricultural uses	--	--	--	--	85	1,270
Chemical and metallurgical:						
Cement manufacture	--	--	--	--	245	1,050
Lime manufacture	--	--	--	--	5	425
Dead-burned dolomite manufacture	--	--	--	--	--	--
Flux stone	--	--	--	--	--	--
Chemical stone	--	--	--	--	--	--
Glass manufacture	--	--	--	--	--	--
Sulfur oxide removal	--	--	--	--	--	--
Special:						
Mine dusting or acid water treatment	--	--	--	--	--	--
Asphalt fillers or extenders	--	--	--	--	189	1,530
Whiting or whiting substitute	--	--	--	--	64	319
Other fillers or extenders	610	18,100	--	--	59	365
Other miscellaneous uses and specified uses not listed	--	--	68	152	1,580	16,500
Unspecified:[3]						
Reported	403	4,650	1,020	4,350	18,400	159,000
Estimated	1,910	18,600	532	6,010	35,200	317,000
Total	3,070	45,900	2,010	14,000	89,400	840,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Totals may not match totals shown in table 2 because of concealments.

[3] Reported and estimated production without a breakdown by end use.

TABLE 14

RECYCLED ASPHALT SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

	2009			2010		
State	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Alabama	127	$2,520	$19.81	133	$2,670	$20.09
Alaska	58	1,200	20.77	31	650	20.85
Arizona	228	1,370	5.99	139	1,200	8.62
Arkansas	86	908	10.61	18	100	5.51
California	1,700	11,600	6.82	1,480	11,400	7.73
Colorado	362	4,050	11.17	377	1,590	4.21
Connecticut	125	517	4.14	141	601	4.26
Delaware	2	35	15.44	(2)	5	14.36
Florida	904	12,300	13.65	77	1,310	17.11
Georgia	197	4,280	21.74	112	1,970	17.55
Hawaii	73	1,030	14.24	--	--	--
Idaho	95	587	6.16	185	1,190	6.42
Illinois	1,470	12,500	8.56	828	6,360	7.67
Indiana	225	1,870	8.29	138	2,850	20.64
Iowa	27	210	7.70	62	227	3.64
Kansas	1,290	33,200	25.73	1,290	32,600	25.34
Kentucky	49	928	19.00	65	457	7.00
Louisiana	135	757	5.59	121	565	4.67
Maine	139	1,130	8.13	61	597	9.86
Maryland	146	703	4.80	120	625	5.21
Massachusetts	288	2,410	8.38	171	1,350	7.90
Michigan	533	3,010	5.66	883	3,560	4.03
Minnesota	531	5,460 r	10.28	445	3,550	7.97
Mississippi	137	1,780	13.04	81	1,570	19.44
Missouri	164	693	4.22	31	120	3.88
Montana	9	89	10.33	50	609	12.22
Nebraska	84	1,090	12.91	36	535	14.87
Nevada	276	1,500	5.45	114	638	5.61
New Hampshire	297	3,480	11.68	301	3,840	12.77
New Jersey	156	1,350	8.66	63	376	5.95
New Mexico	47 r	262 r	5.57	150	749	5.00
New York	382	2,840	7.45	299	2,160	7.22
North Carolina	875	7,850	8.96	931	9,610	10.33
North Dakota	42	450	10.74	23	294	12.59
Ohio	179	1,090	6.10	123	717	5.83
Oklahoma	118	1,570	13.28	69	657	9.52
Oregon	217	1,580	7.25	87	832	9.56
Pennsylvania	1,020	10,100	9.96	572	5,110	8.92
Rhode Island	67	642 r	9.59	20	114	5.62
South Carolina	205	4,420	21.54	269	3,500	12.99
South Dakota	122	752	6.18	112	1,260	11.26
Tennessee	198	1,450	7.34	108	747	6.91
Texas	616	4,650	7.54	259	2,000	7.74
Utah	235	1,560	6.64	37	248	6.71
Vermont	29	426	14.58	55	1,030	18.67
Virginia	233	2,980	12.78	275	2,750	10.01
Washington	170	948 r	5.59	114	767	6.74
West Virginia	--	--	--	--	--	--
Wisconsin	625	4,290	6.86	352	3,350	9.53
Wyoming	15	205	13.94	5	33	6.72
U.S. total or average	15,300 r	161,000 r	10.50	11,400	119,000	10.44

See footnotes at end of table.

TABLE 14—Continued

RECYCLED ASPHALT SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2009 Quantity (thousand metric tons)	2009 Value (thousands)	2009 Unit value	2010 Quantity (thousand metric tons)	2010 Value (thousands)	2010 Unit value
Territory						
Puerto Rico	45	$186 r	$4.13	45.00	$186	$4.13
Grand total or average	15,400 r	161,000 r	10.48	11,400	119,000	10.41

rRevised. -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Less then ½ unit.

TABLE 15

RECYCLED CONCRETE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2009			2010		
	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Alabama	51	$377	$7.34	(2)	$1	$8.17
Alaska	26	124	4.76	61	300	4.96
Arizona	69	485	7.00	25	269	10.71
Arkansas	43	193	4.53	27	60	2.20
California	1,780 [r]	14,200 [r]	7.94	2,860	20,900	7.31
Colorado	721 [r]	5,010 [r]	6.94	582	3,710	6.38
Connecticut	41	328	8.01	91	647	7.07
Delaware	7	75	11.02	108	598	5.51
Florida	424	4,830	11.40	304	3,400	11.19
Georgia	83	274	3.29	99	2,020	20.34
Hawaii	22	215	9.64	6	70	12.23
Idaho	32	192	6.05	181	1,090	6.00
Illinois	1,180	8,820	7.50	836	5,720	6.85
Indiana	139	753	5.43	114	863	7.54
Iowa	28	239	8.39	240	1,170	4.88
Kansas	298	2,230	7.49	275	1,870	6.80
Kentucky	441	4,370	9.92	--	--	--
Louisiana	7	71	10.21	39	691	17.75
Maine	39	294	7.53	26	198	7.68
Maryland	389	2,030	5.21	294	1,330	4.53
Massachusetts	192	1,610	8.39	142	1,340	9.42
Michigan	1,010	7,180	7.13	1,210	8,030	6.66
Minnesota	782 [r]	4,890 [r]	6.25	571	4,250	7.44
Mississippi	71	1,550	21.85	133	1,990	14.96
Missouri	1	2	4.37	37	322	8.76
Montana	20	156	7.97	34	282	8.34
Nebraska	122	1,120	9.19	128	1,070	8.38
Nevada	94	561	5.98	42	255	6.02
New Hampshire	12	109	8.87	8	77	9.07
New Jersey	583	4,730	8.11	195	1,360	6.97
New Mexico	1	2	1.10	5	38	7.71
New York	338	2,620	7.74	250	2,070	8.28
North Carolina	144	1,850	12.86	222	2,490	11.22
North Dakota	17	188	11.23	6	63	11.43
Ohio	337	2,230	6.60	349	2,380	6.81
Oklahoma	224	2,940	13.14	87	1,050	11.99
Oregon	101	882	8.76	70	733	10.44
Pennsylvania	420	2,450	5.83	352	1,740	4.94
Rhode Island	127	948 [r]	7.48	84	583	6.91
South Carolina	216	3,630	16.79	219	3,310	15.07
South Dakota	110	535	4.89	92	537	5.85
Tennessee	25	149	6.02	22	95	4.41
Texas	859	6,750	7.86	34	273	7.96
Utah	224	1,890	8.45	280	2,340	8.37
Vermont	22	102	4.59	4	20	5.38
Virginia	631	5,680	9.01	674	6,010	8.91
Washington	216	1,360 [r]	6.31	307	1,740	5.67
West Virginia	--	--	--	--	--	--
Wisconsin	369	1,940	5.24	1,710	9,160	5.36
Wyoming	58	339	5.86	14	77	5.53
U.S. total or average	13,100 [r]	103,000 [r]	7.87	13,400	98,600	7.33

See footnotes at end of table.

TABLE 15—Continued

RECYCLED CONCRETE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2009			2010		
	Quantity (thousand metric tons)	Value (thousands)	Unit value	Quantity (thousand metric tons)	Value (thousands)	Unit value
Territory						
Puerto Rico	--	--	--	--	--	--
Grand total or average	13,100 r	$103,000 r	$7.87	13,400	$98,600	$7.33

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.

[2] Less then ½ unit.

TABLE 16

CRUSHED AND BROKEN STONE OPERATIONS IN THE UNITED STATES IN 2010, BY STATE[1]

State	Active operations	Active quarries	Dredging operations	Processing plants				Sales yards
				Stationary	Portable	Stationary and portable	None or unspecified	
Alabama	84	72	--	57	8	4	3	12
Alaska	29	35	--	4	18	1	5	1
Arizona	65	67	--	28	26	5	2	4
Arkansas	81	79	--	37	29	7	5	3
California	168	151	1	78	41	11	9	28
Colorado	53	47	--	13	26	1	5	8
Connecticut	35	33	--	19	12	1	1	2
Delaware	4	--	--	--	--	--	--	4
Florida	121	99	2	38	41	10	4	26
Georgia	91	81	--	70	7	--	3	11
Hawaii	24	25	--	8	13	3	--	--
Idaho	48	77	--	9	31	1	7	--
Illinois	158	135	1	75	46	7	5	24
Indiana	102	95	--	82	4	3	5	8
Iowa	180	210	1	27	137	1	11	3
Kansas	79	93	--	22	44	6	2	5
Kentucky	90	89	--	70	9	9	1	1
Louisiana	20	4	--	2	1	1	--	16
Maine	27	23	--	13	5	3	2	4
Maryland	43	31	--	20	3	2	5	13
Massachusetts	50	46	--	28	11	3	3	5
Michigan	43	36	--	22	7	1	1	12
Minnesota	46	51	--	12	23	1	4	6
Mississippi	24	6	--	4	1	1	--	18
Missouri	217	222	--	111	80	12	11	3
Montana	26	42	--	7	19	--	--	--
Nebraska	14	11	1	7	3	--	--	3
Nevada	27	27	--	18	8	--	--	1
New Hampshire	29	27	--	14	7	2	4	2
New Jersey	25	21	--	15	--	6	--	4
New Mexico	48	48	--	12	27	4	4	1
New York	131	126	1	85	26	9	4	6
North Carolina	137	119	--	102	11	3	2	19
North Dakota	9	6	--	--	6	--	--	3
Ohio	117	106	--	71	23	7	3	13
Oklahoma	72	71	--	51	9	3	6	3
Oregon	175	189	--	46	115	4	6	4
Pennsylvania	261	261	--	186	29	14	23	9
Rhode Island	8	6	--	6	--	--	--	2
South Carolina	44	32	--	30	1	1	--	12
South Dakota	16	13	--	8	3	2	--	3
Tennessee	130	127	--	111	11	2	2	4
Texas	258	262	--	127	69	13	18	31
Utah	36	36	--	11	18	--	5	2
Vermont	44	43	--	17	18	4	4	1
Virginia	121	103	--	82	8	6	3	22
Washington	119	135	--	38	55	7	15	4
West Virginia	36	32	--	25	2	3	1	5
Wisconsin	160	221	--	47	87	5	15	6
Wyoming	28	26	--	7	18	1	--	2
Total	3,953	3,897	7	1,972	1,196	190	209	379

-- Zero.

[1] Includes recycle plants.

TABLE 17
U.S. EXPORTS OF CRUSHED STONE IN 2010, BY DESTINATION[1]

Destination		Limestone	Limestone for cement manufacturing	Chalk, crude	Granules, chippings	Other	Total
North America	metric tons	49,300	647,000	418	93,800	365,000	1,160,000
South America	do.	217	18	2	1,800	694	2,730
Europe	do.	2,310	2,070	166	841	27,400	32,800
Asia	do.	46	518	91	162	7,510	8,330
Oceania	do.	3,040	--	25	19	783	3,870
Middle East	do.	1,040	72	--	2,570	5,310	8,990
Africa	do.	--	--	--	4	76	80
Total:							
Quantity	do.	55,900	649,000	701	99,200	407,000	1,210,000
Value	thousands	$2,550	$14,000	$1	$13,800	$21,700	$52,100

do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 18
U.S. IMPORTS OF CRUSHED STONE AND CALCIUM CARBONATE FINES, BY TYPE[1]

Type	2009			2010		
	Quantity (thousand) metric tons)	Value, c.i.f.[2] (thousands)	Unit value	Quantity (thousand) metric tons)	Value, c.i.f.[2] (thousands)	Unit value
Crushed stone and chips:						
Limestone	3,900	$36,900	$9.45	8,900	$74,700	$8.39
Limestone for flux or cement manufacturing	1,040	9,490	9.15	940	12,300	13.11
Other	7,260	125,000	17.21	4,710	96,600	20.52
Total or average	12,200	171,000	XX	14,500	184,000	XX
Calcium carbonate fines:[3]						
Natural chalk	25	1,300	53.05	1	100	129.14
Calcium carbonates, other chalk	2	1,600	930.30	1	1,210	935.73
Total or average	26	2,900	XX	2	1,310	XX
Grand total or average	12,200	174,000	XX	14,600	185,000	XX

XX Not applicable.

[1] Data are rounded to no more than three significant digits, except unit value; may not add to totals shown.
[2] Cost, insurance, and freight value.
[3] Excludes precipitated calcium carbonate.

Source: U.S. Census Bureau.

TABLE 19

THE TOP 100 PRODUCERS OF CRUSHED STONE IN THE UNITED STATES IN 2010[1]

2010 Rank	2009 Rank	Company	2010 Rank	2009 Rank	Company
1	1	Vulcan Materials Co.	51	73	The DePaul Group
2	2	Martin Marietta Aggregates	52	59	Mathy Construction Co.
3	3	Lehigh Hanson, Inc.	53	56	The Heritage Group
4	4	Oldcastle Materials, Inc.	54	54	Aggregate Management, Inc.
5	6	Lafarge North America Inc.	55	58	Trap Rock Industries, Inc.
6	5	CEMEX S.A.B. de C.V.	56	48	Great Lakes Aggregates Inc.
7	9	Carmeuse Lime & Stone	57	70	MGQ Aggregates, Inc.
8	7	Rogers Group, Inc.	58	40	Omya Inc.
9	8	Holcim Group/Aggregate Industries Management Inc.	59	74	Imerys
10	10	New Enterprise Stone & Lime Co., Inc.	60	76	The Melvin Stone Co.
11	12	Luck Stone Corp.	61	67	Wendling Quarries Inc.
12	13	Dolese Bros. Co.	62	88	Snyder Associated Cos., Inc.
13	15	Ash Grove Cement Co.	63	63	Alamo Cement Co.
14	17	Mulzer Crushed Stone, Inc.	64	55	Hinkle Contracting Corp.
15	11	Lhoist S.A.	65	72	United States Lime & Minerals, Inc.
16	16	Ready Mix USA Holding Co.	66	92	Chantilly Crushed Stone, Inc.
17	19	Texas Industries, Inc.	67	86	Laurel Aggregates, Inc.
18	21	National Lime & Stone Co.	68	65	RiverStone Group, Inc.
19	20	Eucon Corp.	69	60	Pete Lien & Sons, Inc.
20	22	MDU Resources Group, Inc.	70	87	Votorantim Cement North America
21	23	The H&K Group	71	—	Savage Stone, LLC
22	24	Buzzi Unicem USA Inc.	72	95	Weldon Materials, Inc.
23	18	Fred Weber, Inc.	73	62	Columbia Quarry Co.
24	26	Mississippi Lime Co.	74	61	ISP Minerals Inc.
25	25	Vecellio & Grogan, Inc.	75	97	Frontera Materials, Inc.
26	27	Tower Rock Stone Co.	76	14	U.S. Forest Service
27	36	Capitol Aggregates Ltd.	77	64	Stavola Construction Materials, Inc.
28	30	Graymont Ltd.	78	69	Granite Construction Inc.
29	29	Eagle Materials Inc.	79	83	Graniterock Co.
30	31	Texas Crushed Stone Co., Inc.	80	89	Kerford Limestone Co.
31	34	Colas Inc.	81	84	Pounding Mill Quarry Corp.
32	47	Titan America LLC	82	—	Rockydale Quarries Corp.
33	33	Franklin Industries, Inc.	83	85	N.R. Hamm Quarry, Inc.
34	37	ESSROC Cement Corp.	84	—	VantaCore Partners LP
35	42	Glenn O. Hawbaker, Inc.	85	90	B.V. Hedrick Gravel & Sand Co., Inc.
36	41	Wake Stone Corp.	86	91	River Products Co., Inc.
37	32	Boxley Materials Co.	87	82	Mitsubishi Cement Corp.
38	44	CalPortland Co.	88	99	Mertens Construction Co., Inc.
39	38	3M Co.	89	75	Syar Industries, Inc.
40	28	Bureau of Land Management	90	78	Jobe Materials, L.P.
41	43	Hunter Industries, Inc.	91	—	Yager Materials
42	39	American Infrastructure	92	—	L.G. Everist, Inc.
43	50	McGeorge Contracting Co.	93	80	Midwest Minerals, Inc.
44	46	Hoover, Inc.	94	—	East Fairfield Coal Co.
45	52	Anchor Stone Co.	95	—	Peckham Industries, Inc.
46	57	Norris Aggregate Products Co.	96	100	Glasgow, Inc.
47	45	Schildberg Construction Co., Inc.	97	96	Paul Niemann Construction Co.
48	68	Greer Industries, Inc.	98	—	Sherwood Construction Co., Inc.
49	53	The Kraemer Co.	99	94	BMC Aggregates, L.C.
50	49	Irving Materials, Inc.	100	—	Albert Frei & Sons, Inc.

— Not in the top 100 producers of crushed stone in the United States in 2009.

[1] In descending order of tonnage produced.

STONE, DIMENSION

By Thomas P. Dolley

Domestic survey data and tables were prepared by Glenn W. Walker, statistical assistant.

U.S. production of dimension stone in 2010 was estimated to be 1.67 million metric tons (Mt) valued at $323 million, which was a 3% increase in tonnage and a slight decrease in value compared with those of 2009 (table 1). Exports increased in value by 13% to $54.5 million, and imports for consumption increased in value by 11% to $1.5 billion. The value of apparent consumption was estimated to be $1.8 billion in 2010, which was a 12% increase compared with that of 2009. World dimension stone production, including the United States, was estimated to be approximately 107 Mt in 2009, the last year for which data were available. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data.

In recent years, most dimension stone has been used in construction applications, with the largest portions being sold or used as ashlars and partially squared pieces, curbing, flagstone, and rough block for building and construction. Monumental stone, another major type, includes memorials of various kinds.

Dimension stone is a natural rock material quarried for the purpose of obtaining blocks or slabs that meet specifications as to size (width, length, and thickness) and shape. Color, grain texture and pattern, and surface finish of the stone also are normal requirements by both customers and the stone industry. Durability (a time measure of the ability of dimension stone to endure and maintain its essential and distinctive characteristics), strength, and the ability of the stone to take a polish are other important selection criteria.

Although various igneous, metamorphic, and sedimentary rocks are used as dimension stone, the principal rock types are granite, limestone, marble, sandstone, and slate. Other varieties of dimension stone that are normally considered to be special minor types include alabaster (massive gypsum) and soapstone (massive talc). A more detailed discussion describing specific types of dimension stone can be found in the 2007 dimension stone Minerals Yearbook chapter.

Production

Dimension stone production data for the United States are derived by the U.S. Geological Survey (USGS) from a voluntary canvass of U.S. quarry producers of rough and dressed dimension stone. Of the 237 dimension stone-producing operations included in the survey for 2010, 173 (53%) responded, which represented 58% of the tonnage; the remaining tonnage was estimated based on prior years' reporting and on employment data provided by the Mine Safety and Health Administration (MSHA).

Data in this report cover rough crude quarried stone, irregular-shaped and rectangular blocks, and more highly processed stone. A number of other terms also are used to describe further processing, such as "worked," "dressed," "finished," and "manufactured." These and other terms used by the dimension stone industry describe such features as the mineral composition of the rock, the shape of the product, the method of finishing a stone, and the type of finish applied. No adjustments are made in the data to account for the sometimes substantial losses in processing rough stone into dressed stone. Sold or used data are considered to be equivalent to production because changes in stocks are not surveyed.

In October, Rock of Ages Corp. was purchased by Swenson Granite Co. for about $38.9 million (Reuters, 2010). In November, the Yule Marble Quarry in Marble, CO, resumed operations after a 10-month closure that was the result of the recession and escalating transportation costs. The quarry reopened after Polycor Inc. sold the underground quarry to Enrico Locati Luciani of Carrara, Italy, in October (KOAA Colorado Springs News, 2011).

In 2010, granite accounted for 699,000 metric tons (t) (42%) of the total domestic dimension stone production of 1.67 Mt, followed by limestone (27%), miscellaneous stone (14%), sandstone (14%), marble (2%), and slate (1%). Granite accounted for about $118 million (36%) of the $323 million total domestic production value, followed by limestone (32%), miscellaneous (14%), sandstone (10%), slate (4%), and marble (4%).

Production of dimension stone was reported in 37 States. Leading producer States were, in descending order by tonnage, Georgia, Texas, Indiana, and Wisconsin. These States accounted for about 46% of domestic production. Leading producer States were, in descending order by value, Texas, Indiana, New York, Georgia, and Wisconsin. These States contributed about 50% of the value of domestic production (table 3).

The top five producing companies were Champlain Stone, Ltd. in New York, Cold Spring Granite Co. in Minnesota, Dixie Quarries Inc. in Georgia, Mezger Enterprises Inc. in Texas, and Victor Oolitic Stone Co. in Indiana. These companies produced about 35% of domestic production in tonnage and about 21% of production value. The leading 14 companies accounted for 58% of total domestically produced tonnage and 44% of the value.

Rough stone blocks split or cut from a quarry face are transported to processing plants that typically are located at the quarry site, at least for preliminary sizing. Further dressing, which includes final sizing and finishing operations, such as decorating, edging, and polishing, also may be done at the quarry site.

Granite.—Dimension granite was produced by 44 companies operating 69 quarries in 15 States. Production was 699,000 t valued at $118 million. Granite production tonnage increased by 49% and the value increased by about 6% compared with those of 2009. The top five producing States were, in descending order by tonnage, Georgia, Massachusetts, North Carolina, Vermont, and New York. The leading producer State, Georgia, accounted for 35% of the tonnage and 14% of the value of U.S. granite production (table 4).

Champlain Stone Ltd., Cold Spring Granite Co., Dixie Quarries Inc., Swenson Granite Co. LLC, and Williams Stone Co. Inc., which were the leading producers, accounted for 71% of U.S. granite production by tonnage and 62% of U.S. granite production by value.

Limestone.—Dimension limestone was produced by 42 companies from 47 quarries in 12 States. Production decreased in 2010 by about 17% to 454,000 t from 548,000 t in 2009. The value decreased by 2% to $104 million in 2010 from $106 million in 2009. The top four producing States were, in descending order by tonnage, Texas, Indiana, Kansas, and Minnesota which combined produced 90% of the U.S. tonnage and 94% of the value (table 5). Buechel Stone Corp., Eden Stone Co. Inc., Higgins Stone Co. Inc., Mezger Enterprises, and Victor Oolitic Stone Co., which were the leading producers, accounted for about 74% of all U.S. limestone tonnage and about 41% of the value.

Sandstone.—Dimension sandstone was produced by 55 companies that operated 68 quarries in 18 States. Production decreased by 8% to 228,000 t in 2010 from 248,000 t in 2009. The value decreased by 9% to $33.2 million in 2010 from $36.7 million in 2009. The top five producing States were, in descending order by tonnage, Arizona, Oklahoma, Pennsylvania, Ohio, and New York (table 6).

Briar Hill Stone Co., Cornerstone Materials LLC, Drake Stone Products Inc., Harley Gray Stone Co., and Jude Stone Quarry Inc., which were the leading producers, accounted for about 43% of the tonnage and 38% of the value of domestic production.

Marble.—Marble was mined by three companies that operated four quarries in three States. Production tonnage decreased by 12% in 2010 to 31,100 t valued at $12.1 million from 35,300 t valued at $12.8 million in 2009 (table 10). Georgia was the leading producing State, followed by Vermont and Tennessee. The leading producers were Georgia Marble Co. (a subsidiary of Polycor Inc.) and Vermont Quarries Corp.

Slate.—Slate was produced by 18 companies that operated 19 quarries in 7 States. Production increased by 6% to 22,900 t in 2010 from 21,600 t in 2009. The value increased slightly to $14.2 million in 2010 from $14 million in 2009 (table 12). The top producing States were Vermont, Virginia, and North Carolina. The leading producers were Buckingham Slate Co., Newmont Slate Co., Inc., and Western Slate Inc.

Consumption

For the purposes of this report, apparent consumption is calculated to be production plus imports for consumption minus exports; changes in industry stocks are not considered because such data are not available. Value data are used in the apparent consumption calculation because tonnage data are not available for imports and exports. Overall, the value of apparent consumption of dimension stone in the United States was estimated to be $1.8 billion in 2010; this was a 12% increase compared with that of 2009.

Rough stone represented about 63% of the tonnage and 42% of the value of all dimension stone sold or used by domestic producers, which included exports. The leading uses of rough stone, by tonnage, were in irregular-shaped stone (45%), and in building and construction (36%). Dressed stone represented 37% by tonnage and 58% by value of the total stone sold or used. The leading uses within dressed stone, by tonnage, were in curbing (26%); ashlars and partially squared pieces (23%); and flagging (18%) (table 7).

Uses for the different varieties of dimension stone varied considerably. The major uses of granite sold or used in 2010, by tonnage, were in irregular-shaped stone (37%), curbing (22%), rough blocks for building and construction (15%), and monumental rough stone (13%) (table 8). Primary uses of limestone, by tonnage, were in rough blocks for building and construction (37%), and in dressed stone for ashlars and partially squared pieces (24%) (table 9). The primary use of marble, by tonnage, was in rough stone, other uses (including slabs and blocks, flagging, monumental, panels and veneer, ashlars and partially squared pieces, tile, and unlisted uses) (81%) (table 10). Primary uses of sandstone, by tonnage, were in dressed stone for flagging (35%), and in rough blocks for building and construction (25%) (table 11). Dimension slate sold or used by producers in the United States in 2010, by tonnage, was principally for roofing (81%), flagging (10%), and flooring (4%) (table 12).

Prices

The average 2010 value for dimension stone was $193 per metric ton, a 4% decrease from that of 2009 based on the USGS canvass data. The average unit values for different types of dimension stone were granite, $168 per ton; limestone, $230 per ton; marble, $388 per ton; sandstone, $145 per ton; and slate, $621 per ton. Available price data show considerable variation. Prices are substantially different not only for the kind of stone, but also for the appearance of the same kind of stone. Color, grain structure, and finish contribute significantly to price and marketability.

Foreign Trade

Exports.—In 2010, the value of total exports of dimension stone increased by 13% in value to $54.5 million compared with that of 2009; granite accounted for 56% of the export value. The largest share of granite was exported to China (table 13). Although unreported, a significant amount of U.S. granite processed overseas was probably exported back to the U.S. market.

Imports.—The value of imports for consumption of dimension stone types increased by 11% in 2010 to $1.5 billion (table 1). Brazil was the leading source of imported granite in 2010, accounting for 43% by value. China, which continued to be a major source of granite, accounted for 22% of granite imports by value. Other important granite import sources included India (14%) and Italy (13%) (table 14). In 2010, China continued to be a major source of rough and dressed marble imports and accounted for 29% by tonnage and 25% by value. Additionally, Italy was a major source of rough and dressed marble imports and accounted for 20% by tonnage and 32% by value (tables 15–16). Duties on imported dimension stone are listed in table 2.

World Review

World dimension stone production, including the United States, was estimated to be approximately 107 Mt in 2009, the last year for which data were available. Although there was probably some small-scale production in the majority of the world's nations, dimension stone was produced and officially reported in about 29 countries. The top five producing countries in 2009 were, in descending order by tonnage, China, India, Turkey, Iran, and Italy, and these countries accounted for about 71% of the world's production. Global production of dimension stone was unchanged in 2009 compared with that of 2008. The United States ranked 10th in world production of dimension stone in 2009 (Napoli, 2011, p. 51).

Outlook

U.S. apparent consumption, production, exports, and imports of dimension stone all increased in 2010, but at different rates. Increases in U.S. imports and apparent consumption, coupled with increased activity from domestic stone installation businesses, indicate that residential and commercial improvement and refurbishment experienced increased activity. Industry observers anticipate slow growth in the global dimension stone industry in the near term (Napoli, 2011).

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TABLE 1

SALIENT U.S. DIMENSION STONE STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2006	2007	2008	2009	2010
Sold or used by producers:					
Quantity	1,850	1,920	1,800	1,620	1,670
Value	334,000	346,000	326,000	328,000	323,000
Exports, value	76,000	74,300	65,700	48,300	54,500
Imports for consumption, value	2,500,000	2,540,000	2,150,000	1,350,000	1,500,000

[1] Data are rounded to no more than three significant digits.

TABLE 2
U.S. IMPORT DUTIES ON DIMENSION STONE

Tariff item	HTS[1] code	NTR,[2] January 1, 2010	Non-NTR,[2] January 1, 2010
Slate, rough blocks or slabs	2514.00.0000	Free	25% ad valorem.
Rough blocks or slabs of marble, travertine, other calcareous monumental or building stone:	2515.00.0000		
Marble and travertine:			
Crude or roughly trimmed	2515.11.0000	Free	$22.95 per cubic meter.
Marble, merely cut	2515.12.1000	do.	13% ad valorem.
Travertine, merely cut	2515.12.2000	3.0% ad valorem	50% ad valorem.
Other calcareous stone alabaster	2515.20.0000	do.	Do.
Rough blocks or slabs of granite, porphyry, basalt, sandstone, other monumental or building stone:	2516.00.0000		
Granite:			
Crude or roughly trimmed	2516.11.0000	Free	$8.83 per cubic meter.
Merely cut	2516.12.0000	2.8% ad valorem	60% ad valorem.
Sandstone:			
Crude or roughly trimmed	2516.20.1000	Free	$5.30 per cubic meter.
Merely cut	2516.20.2000	3.0% ad valorem	50% ad valorem.
Other monumental or building stone	2516.90.0000	do.	Do.
Setts, curbstones, flagstones	6801.00.0000	2.8% ad valorem	60% ad valorem.
Worked monumental or building stone:	6802.00.0000		
Tiles and cubes under 7 centimeters square, granules	6802.10.0000	4.8% ad valorem	40% ad valorem.
Other stone and articles with a flat or even surface:			
Marble, travertine, and alabaster:	6802.21.0000		
Travertine	6802.21.1000	4.2% ad valorem	50% ad valorem.
Other	6802.21.5000	1.9% ad valorem	13% ad valorem.
Granite	6802.23.0000	3.7% ad valorem	60% ad valorem.
Other calcareous stone	6802.29.1000	4.9% ad valorem	50% ad valorem.
Other stone	6802.29.9000	6.0% ad valorem	30% ad valorem.
Other:			
Marble, travertine, and alabaster:	6802.91.0000		
Marble:			
Slabs	6802.91.0500	2.5% ad valorem	15% ad valorem.
Other	6802.91.1500	4.9% ad valorem	50% ad valorem.
Travertine:			
Travertine articles of subheading 6802.21.1000 that have been dressed or polished, but not further worked	6802.91.2000	4.2% ad valorem	50% ad valorem.
Other	6802.91.2500	3.7% ad valorem	40% ad valorem.
Alabaster	6802.91.3000	4.7% ad valorem	50% ad valorem.
Other calcareous stone	6802.92.0000	4.9% ad valorem	Do.
Granite	6802.93.0000	3.7% ad valorem	60% ad valorem.
Other stone	6802.99.0000	6.5% ad valorem	40% ad valorem.
Worked slate and articles:	6803.00.0000		
Roofing slate	6803.00.1000	3.3% ad valorem	25% ad valorem.
Other	6803.00.5000	Free	Do.

Do., do. Ditto.

[1] Harmonized Tariff Schedule of the United States.

[2] Normal trade relations.

TABLE 3
DIMENSION STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2009		2010	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Alabama	4,020	$1,460	W	W
Arizona	94,500	13,800	81,400	$11,700
Arkansas	18,300	2,360	19,800	1,600
California	24,500	6,100	26,100	6,940
Colorado	9,610 [r]	3,040 [r]	7,530	1,740
Georgia	148,000 [r]	15,800 [r]	264,000	25,500
Idaho	25,200	3,370	25,100	3,520
Indiana	206,000	41,500	173,000	31,400
Kansas	29,200	4,650	46,600	4,720
Maine	5,800	1,300	8,000	1,250
Maryland	W	W	7,560	1,630
Massachusetts	43,800	6,130	73,300	21,700
Minnesota	25,100	16,700	34,700	15,400
Montana	W	W	11,000	2,950
New Hampshire	34,800	4,880	W	W
New Mexico	32,300	986	W	W
New York	98,600 [r]	28,400 [r]	95,600	26,000
North Carolina	66,500 [r]	23,400 [r]	63,000	21,800
Ohio	25,800	4,790	25,100	4,440
Oklahoma	35,700 [r]	4,400 [r]	29,700	2,750
Pennsylvania	36,700	9,500	25,200	5,860
South Carolina	3,390	401	W	W
Texas	236,000	42,000	195,000	57,000
Utah	8,700	844	8,700	674
Vermont	108,000	30,000	68,400	21,900
Virginia	W	W	13,700	3,920
Wisconsin	207,000	29,800	144,000	2,320
Other[2]	94,600	33,400	223,000	46,300
Total	1,620,000	328,000	1,670,000	323,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Alabama (2010), Connecticut, Illinois, Maryland (2009), Michigan, Missouri, Montana (2009), Nevada, New Hampshire (2010), New Mexico (2010), South Carolina (2010), South Dakota, Tennessee, Virginia (2009), Washington, West Virginia, and Wyoming.

TABLE 4
DIMENSION GRANITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
California	13,300	$3,330	14,700	$4,230
Georgia	135,000 [r]	10,200 [r]	244,000	16,900
Maine	5,800	1,300	8,000	1,250
Massachusetts	34,900	4,760	69,600	20,600
New Hampshire	34,800	4,880	W	W
New York	W	W	28,900	13,100
North Carolina	54,300 [r]	22,100 [r]	52,800	20,800
South Carolina	3,390	401	W	W
Vermont	82,000	19,100	41,400	9,390
Other[2]	105,000	45,300	239,000	31,500
Total	469,000	111,000	699,000	118,000

[r] Revised. W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Maryland, Minnesota, Missouri, New Hampshire (2009), New York (2009), Oklahoma, South Carolina (2009), South Dakota, Texas, Virginia, and Wisconsin.

TABLE 5
DIMENSION LIMESTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Arkansas	885	$98	W	W
Indiana	206,000	41,500	173,000	$31,400
Kansas	W	W	45,500	4,540
Minnesota	W	W	9,740	7,340
Texas	223,000	39,500	182,000	54,500
Wisconsin	49,100	4,730	W	W
Other[2]	69,200	20,400	44,000	6,600
Total	548,000	106,000	454,000	104,000

W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Alabama, Arkansas (2010), California, Illinois, Kansas (2009), Maryland, Minnesota (2009), New York, Ohio, Pennsylvania, and Wisconsin.

TABLE 6
DIMENSION SANDSTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY STATE[1]

State	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Arizona	94,500	$13,800	81,400	$11,700
Arkansas	17,400	2,260	9,860	1,470
Colorado	W	W	7,530	1,740
New York	15,900	3,350	12,400	2,200
Ohio	20,900	4,540	17,200	4,100
Oklahoma	23,500 [r]	3,060 [r]	29,700	2,750
Pennsylvania	19,300	2,370	18,100	3,770
Other[2]	56,800 [r]	7,260 [r]	52,000	5,430
Total	248,000	36,700	228,000	33,200

[r] Revised. W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes California, Colorado (2009), Idaho, Kansas, Michigan, North Carolina, Texas, Utah, West Virginia, and Wisconsin.

TABLE 7
DIMENSION STONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Rough stone:				
Rough blocks for building and construction	402,000	$64,900	378,000	$66,800
Irregular-shaped stone	259,000	27,800	475,000	25,300
Monumental	164,000	30,600	113,000	22,900
Other[2]	26,900	7,310	89,500	19,400
Dressed stone:				
Ashlars and partially squared pieces	185,000	42,200	144,000	30,500
Slabs and blocks for building and construction	66,500	22,000	58,800	36,700
Monumental	26,900	12,800	25,600	10,900
Curbing	145,000	19,300	162,000	32,400
Flagging	115,000	14,900	108,000	13,600
Flagging (slate)	3,640	2,270	2,380	903
Panels and veneer	W	W	43,500	36,400
Roofing slate	15,800	9,160	18,700	11,300
Flooring slate	640	933	1,180	1,920
Tile, all dimensions	W	W	2,200	2,050
Other[3]	206,000	73,700	48,000	12,200
Total	1,620,000	328,000	1,670,000	323,000

W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes flagging stone, exports, uses not specified, and uses not listed.

[3] Includes panels and veneer, blackboards, exports, uses not specified, structural and sanitary, and uses not listed.

TABLE 8

DIMENSION GRANITE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Rough stone:				
Rough blocks for building and construction	84,000	$16,600	103,000	$26,500
Irregular-shaped stone	13,800	1,060	261,000	756
Monumental	133,000	24,100	93,700	15,800
Other[2]	33,600	6,310	38,000	7,440
Dressed stone:				
Ashlars and partially squared pieces	12,100	3,910	8,630	2,550
Slabs and blocks for building and construction	920	1,090	1,200	883
Monumental	26,900	12,700	25,500	10,900
Curbing	138,000	18,500	154,000	31,600
Other[3]	27,100	27,000	14,300	21,300
Total	469,000	111,000	699,000	118,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes exports and uses not listed.

[3] Includes panels and veneer, tile, uses not specified, and uses not listed.

TABLE 9

DIMENSION LIMESTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Rough stone:				
Rough blocks for building and construction	200,000	$33,500	170,000	$27,100
Irregular-shaped stone	115,000	10,100	101,000	8,810
Other[2]	4,790	1,820	10,400	4,930
Dressed stone:				
Ashlars and partially squared pieces	133,000	28,200	107,000	19,800
Slabs and blocks for building and construction	28,600	10,100	25,400	25,300
Flagging	11,100	2,170	5,910	1,190
Panels veneer	W	W	21,700	12,100
Other[3]	55,300	20,500	12,100	5,200
Total	548,000	106,000	454,000	104,000

W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes exports, monumental, and uses not listed.

[3] Includes curbing limestone, panels and veneer, tile, uses not specified, and uses not listed.

TABLE 10

DIMENSION MARBLE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1, 2]

Use	2009		2010	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	9,610	$1,640	W	W
Other[3]	14,500	5,910	25,300	$8,460
Dressed stone[3]	11,200	5,260	W	W
Total	35,300	12,800	31,100	12,100

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes monumental stone, uses not specified, and uses not listed.

[3] Includes slabs and blocks, flagging, monumental, panels and veneer, ashlars and partially squared pieces, tile, and uses not listed.

TABLE 11

DIMENSION SANDSTONE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2009		2010	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Rough stone:				
Rough blocks for building and construction	67,100	$6,890	57,800	$5,940
Irregular-shaped stone	37,800	5,590	25,100	2,910
Other[2]	17,000	3,270	20,400	4,240
Dressed stone:				
Ashlars and partially squared pieces	21,400	4,080	18,800	3,870
Flagging	79,200	9,360	80,900	9,180
Panels and veneer	6,280	1,370	5,710	1,790
Slabs and blocks for building and construction	3,880	871	2,910	1,280
Other[3]	15,700	5,220	16,600	3,990
Total	248,000	36,700	228,000	33,200

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes flagging stone and uses not listed.

[3] Includes tile, curbing, exports, uses not specified, and uses not listed.

TABLE 12

DIMENSION SLATE SOLD OR USED BY PRODUCERS IN THE UNITED STATES, BY USE[1]

Use	2009		2010	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Flagging	3,640	$2,270	2,380	$903
Roofing	15,800	9,160	18,700	11,300
Flooring	640	933	1,010	1,470
Other[2]	1,600	1,620	873	613
Total	21,600	14,000	22,900	14,200

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes structural and sanitary purposes, uses not specified, and uses not listed.

TABLE 13

U.S. EXPORTS OF DIMENSION STONE, BY TYPE[1]

(Thousand metric tons and thousand dollars)

Type	2009 Quantity	2009 Value	2010 Quantity	2010 Value	Major destination in 2010[2]
Marble, travertine, alabaster worked[3]	43	5,580	51	7,830	Canada, 37%.
Marble, travertine, crude or roughly trimmed	2	1,250	1	429	The Bahamas, 19%.
Marble, travertine, merely cut, by sawing or otherwise[4]	4	2,010	2	1,650	Canada, 19%.
Granite, crude or roughly trimmed	67	20,800	77	25,200	China, 69%.
Granite, merely cut by sawing or otherwise[4]	8	3,310	19	5,420	China, 67%.
Sandstone, crude or roughly trimmed	NA	NA	NA	NA	NA.
Sandstone, merely cut, by sawing or otherwise[4]	NA	NA	NA	NA	NA.
Slate, worked and articles of slate	NA	4,340	NA	2,850	Canada, 73%.
Slate, whether or not roughly trimmed or merely cut[4]	NA	789	NA	475	Latvia, 37%.
Other calcareous monumental or building stone; alabaster[5]	22	6,290	28	7,600	Canada, 89%.
Other monumental or building stone[6]	15	3,870	17	3,040	Canada, 78%.
Total	XX	48,300	XX	54,500	

NA Not available. XX Not applicable.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] By value.

[3] Further worked than simply cut with a flat surface.

[4] Blocks or slabs.

[5] Crude, roughly trimmed, or merely cut into blocks or slabs. Other than marble and travertine (includes alabaster).

[6] Crude, roughly trimmed, or merely cut into blocks or slabs. Other than calcareous stone and alabaster, granite, sandstone, slate, dolomite, quartzite, and steatite.

Source: U.S. Census Bureau.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF DIMENSION GRANITE, BY COUNTRY[1]

(Thousand dollars)

		Dressed								
			Worked granite							
				Cut to size[2]						
Country	Rough granite[3]	Simply cut[4]	Not cut to size[5]	Maximum 1.5 centimeters	1.5-7.5 centimeters	Monumental minimum 7.5 centimeters	Building minimum 7.5 centimeters	Other	Total worked	Total dressed
2009:										
Argentina	192	3	83	--	486	--	--	21	590	593
Brazil	722	2,660	60,200	3,410	184,000	67	3,010	30,400	281,000	284,000
Canada	3,130	471	1,660	2,290	6,870	9,980	1,790	3,090	25,700	26,200
China	1,690	15,600	9,610	14,200	105,000	12,900	11,400	46,600	200,000	216,000
Finland	10	--	--	--	25	--	--	13	38	38
India	5,430	4,140	13,300	2,140	49,100	8,930	2,390	15,500	91,300	95,500
Italy	553	1,580	16,400	1,720	65,400	--	3,420	16,200	103,000	105,000
Japan	2	--	--	--	9	--	193	11	213	213
Mexico	5	181	--	--	83	--	10	207	300	481
Norway	230	6	--	12	35	--	--	16	63	69
Portugal	--	24	20	45	139	--	37	223	464	488
Saudi Arabia	--	--	--	--	166	--	3	29	198	198
South Africa	658	3	54	--	150	--	4	24	232	235
Spain	69	315	570	289	5,650	--	31	811	7,350	7,670
Zimbabwe	1,900	--	--	--	--	--	--	--	--	--
Other	744	2,020	6,110	756	14,300	122	772	3,210	25,300	27,300
Total	15,300	27,000	108,000	24,800	432,000	32,000	23,100	116,000	736,000	763,000
2010:										
Argentina	43	--	239	--	534	--	--	221	994	994
Brazil	133	2,070	87,900	3,050	268,000	--	6,040	47,000	412,000	414,000
Canada	3,060	940	816	1,590	4,960	7,790	4,070	3,770	23,000	23,900
China	1,890	11,200	12,500	9,080	107,000	14,700	11,300	49,600	204,000	215,000
Finland	--	--	--	--	3	--	4	20	27	27
India	7,550	2,230	15,700	2,940	73,600	8,400	2,510	22,600	126,000	128,000
Italy	336	2,560	16,500	1,830	77,900	48	2,440	19,600	118,000	121,000
Japan	--	114	--	--	--	--	--	12	12	126
Mexico	--	158	--	--	225	--	6	386	617	775
Norway	336	13	--	--	115	--	--	23	138	151
Portugal	--	33	--	54	92	--	2	111	259	292
Saudi Arabia	--	14	1,820	--	5,430	--	31	343	7,620	7,630
South Africa	756	85	84	--	100	--	4	149	337	422
Spain	21	399	1,350	298	6,450	--	239	738	9,070	9,470
Sweden	13	--	--	--	--	--	--	--	--	--
Zimbabwe	--	--	--	--	--	--	--	--	--	--
United Kindom	410	--	261	--	--	--	--	62	323	323
Other	492	1,330	5,310	486	15,200	49	767	3,270	25,100	26,400
Total	15,000	21,200	142,000	19,300	559,000	31,000	27,500	148,000	927,000	949,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] One or more faces worked more than simply cut.

[3] Normal quarry products. Includes crude or roughly trimmed and roughly cut by sawing or otherwise; Harmonized Tariff Schedule of the United States (HTS) codes 2516.11.0000, 2516.12.0030, and 2516.12.0060.

[4] Simply cut with a flat even surface; HTS code 6802.23.0000.

[5] Only one face worked more than simply cut; HTS code 6802.93.0010.

Source: U.S. Census Bureau.

TABLE 15

U.S. IMPORTS FOR CONSUMPTION OF MAJOR CATEGORIES OF DIMENSION MARBLE AND OTHER CALCAREOUS STONE, BY COUNTRY[1]

	Dressed							
	Marble, slabs[2]		Marble, other[3]		Other calcareous stone[4]		Rough marble[5]	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
2009:								
Brazil	1,680	$1,680	170	$193	715	$955	22	$36
Canada	151	438	455	1,900	9,230	5,420	1	3
China	47,500	33,700	43,900	49,000	36,200	13,400	1,970	865
France	37	185	185	609	5,710	10,500	3	7
Greece	3,600	8,110	2,530	4,850	479	785	--	--
India	3,830	3,700	2,120	3,580	3,850	2,700	6	19
Israel	2,720	3,500	3,700	3,710	5,180	6,180	--	--
Italy	41,600	80,100	25,800	43,500	14,600	18,500	376	481
Lebanon	4	3	524	991	469,000	5,650	22	12
Mexico	393	468	2,070	2,800	5,810	6,130	142	28
Portugal	1,220	1,530	908	1,740	14,200	13,800	4	16
Spain	18,000	17,100	14,900	17,200	12,000	11,800	448	227
Taiwan	437	506	1,120	2,120	80	88	5	30
Turkey	19,400	15,400	49,400	38,900	44,400	6,030	175	132
Other	10,900	9,910	14,100	13,400	41,300	12,700	299	157
Total	151,000	176,000	162,000	185,000	663,000	115,000	3,470	2,010
2010:								
Brazil	1,730	1,800	104	99	809	894	--	--
Canada	191	662	439	1,300	3,820	4,530	--	--
China	48,900	37,300	43,300	50,000	11,200	10,800	1,800	821
France	194	338	365	638	7,230	6,330	1	3
Greece	2,370	4,600	1,640	3,330	440	511	--	--
India	3,370	3,070	2,300	3,490	6,150	1,070	46	50
Israel	1,830	2,050	2,210	2,500	5,260	4,840	1	4
Italy	43,600	75,900	21,100	35,700	11,000	15,100	174	536
Lebanon	1	4	127	472	202,000	2,210	--	--
Mexico	345	282	1,900	2,770	5,800	6,370	35	21
Portugal	906	1,330	753	1,230	9,960	9,890	--	--
Spain	21,200	19,000	15,700	14,600	17,600	7,520	307	186
Taiwan	369	425	1,330	2,340	98	91	3	4
Turkey	19,400	17,100	66,500	48,500	19,800	6,260	818	106
Other	8,770	6,980	13,700	13,100	42,400	12,700	518	381
Total	153,000	171,000	171,000	180,000	343,000	89,100	3,710	2,110

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Worked more than simply cut with a flat surface; Harmonized Tariff Schedule of the United States (HTS) code 6802.91.0500.

[3] Merely cut by sawing or otherwise.

[4] Worked more than simply cut with a flat surface, other than marble and travertine; HTS code 6802.92.0000.

[5] Simply cut by sawing or otherwise into rectangular blocks or slabs; HTS code 2515.12.1000.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 16

U.S. IMPORTS FOR CONSUMPTION OF DIMENSION STONE, BY TYPE[1]

Type		2009 Quantity	2009 Value (thousands)	2010 Quantity	2010 Value (thousands)	Major source for 2010[2]
Calcareous stone, other[3]	metric tons	NA	NA	NA	NA	NA.
Marble and alabaster[4]	do.	12,300	$16,000	13,000	$16,400	China, 21%.
Sandstone, cut, by sawing or otherwise[5]	do.	NA	NA	NA	NA	Italy, NA.
Slate, roofing	million square feet	6	5,910	6	6,360	Canada, 40%.
Slate, roughly trimmed or simply cut[5]	do.	3,190	1,220	6,400	2,090	China, 64%.
Slate, worked and articles of slate, and other[6]	do.	NA	56,000	NA	54,700	China, 41%.
Travertine, monumental or building stone and articles thereof[7]	do.	14,600	13,000	20,300	13,900	Mexico, 31%.
Travertine, worked monumental or building stone[8]	do.	21,200	16,300	28,700	18,300	China, 41%.
Other stone, monumental or building stone[9]	do.	NA	NA	NA	NA	Turkey, NA.

do. Ditto. NA Not available.

[1] Data are rounded to no more than three significant digits. Table does not include totals shown on tables 14 and 15.

[2] By value.

[3] Simply cut with a flat surface, other than marble, travertine, and alabaster.

[4] Simply cut with a flat surface.

[5] Rectangular blocks or slabs.

[6] Other than roofing, including agglomerated slate.

[7] Simply cut with a flat surface, other than tiles and granules.

[8] Dressed or polished but not further worked.

[9] Simply cut with a flat surface, other than granite, calcareous stone, alabaster, slate, dolomite, quartzite, and steatite.

Source: U.S. Census Bureau.

STRONTIUM

By Marc A. Angulo

Domestic survey data and tables were prepared by Maria Arguelles, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Domestic apparent strontium consumption decreased in 2010, attributed primarily to a decrease in imported celestite. The 10,400 metric tons (t) of strontium content consumed in 2010 was dramatically lower than the nearly 38,000 t consumed at its peak in 1997. Strontium minerals were not mined in the United States in 2010, although deposits have been identified and were mined in the past. World production of celestite increased from 400,000 t in 2009 to 405,000 t in 2010.

Strontium composes about 0.04% of the Earth's crust, ranking 15th among elements in abundance (MacMillan and others, 2005). Owing to its high reactivity to air and water, strontium metal is not found in nature in its metallic form. The two strontium-bearing minerals, celestite (strontium sulfate) and strontianite (strontium carbonate), contain strontium in sufficient quantities to make recovery practical. Of the two, celestite occurs much more frequently in sedimentary deposits of sufficient size to make development of mining facilities attractive.

Legislation and Government Programs

Strontium may be found in trace amounts in drywall, but the occurrence of foul odor, electrical corrosion, and illness associated with homes fitted with Chinese-manufactured drywall led Florida State and Federal investigators to suspect the presence of elevated strontium sulfide levels. An initial study conducted by the Florida Department of Health found trace amounts of strontium sulfide in Chinese drywall and none in domestic drywall. The Environmental Protection Agency found elevated strontium and sulfur levels in Chinese drywall. A joint study conducted in 2010 by the U.S. Consumer Product Safety Commission and the U.S. Department of Housing and Urban Development concluded that strontium was not a good indicator for the identification of tainted Chinese drywall in a home and strontium did not play a causal role in the problems associated with the tainted drywall (Florida Department of Health, 2009; U.S. Environmental Protection Agency, 2009; Federal Interagency Task Force on Problem Drywall, 2010).

Production

Although strontium carbonate was not produced in the United States in 2010, strontium carbonate was the principal strontium compound produced globally in 2010, and most other strontium compounds were derived from strontium carbonate. Domestic production of strontium carbonate ceased in 2006 with the closure of the Chemical Products Corp. strontium carbonate and strontium nitrate operations. A few companies produced small quantities of downstream strontium chemicals elsewhere in the United States.

Consumption

Strontium compounds were mostly consumed by the ceramic, glass, and pyrotechnics industries, with smaller amounts consumed by a multitude of other industries. Strontium carbonate is used directly in some applications and is also converted into appropriate downstream chemicals such as strontium chloride, strontium hydroxide, or strontium nitrate. Celestite is typically used as the raw material in strontium carbonate production and is consumed directly in small quantities as an alternative to barium sulfate as white filler in industrial products.

Permanent ceramic ferrite magnets are used extensively in small direct current motors for automobile windshield wipers, loudspeakers, magnetically attached decorative items, toys, and other electronic equipment. Strontium ferrite magnets possess the chemical and physical properties ideal for use in these applications, such as resistance to corrosion and demagnetization, low densities, and effectiveness at high temperatures (Haberberger, 1971). Strontium oxide and strontium carbonate are used as frits in ceramic glazes as a nontoxic alternative to barium and lead (Yunpeng, 2009). Strontium oxide is used as a glass modifier to increase hardness and strength, enhance optical glass properties, and increase light refraction. Strontium glass is colorless and absorbs ultraviolet and x-ray radiation, an ideal glass for cathode ray tube (CRT) faceplates. The fiberglass, lab glass, and pharmaceutical glass industries consume strontium in smaller amounts.

Strontium nitrate is used most often as a coloring agent in pyrotechnic applications, but strontium carbonate, strontium chloride, strontium oxalate, and strontium sulfate can also be used. Strontium pyrotechnic applications include civilian and military flares, fireworks, and tracer ammunition (Conkling, 1981).

Strontium is used in a few metallurgical applications. Strontium metal is added to aluminum alloys to improve castings used in automotive and aerospace applications (Metallurg Aluminum, 2006). Strontium can be used to remove lead impurities during the electrolytic production of zinc. The addition of strontium carbonate dissolved in sulfuric acid reduces the lead content of the electrolyte and of the zinc deposited on the cathode.

Strontium chromate was incorporated into paints as a corrosion inhibitor, effectively coating aluminum used in the construction of aircraft fuselages and ships (Roskill Information Services Ltd., 1992, p. 76). Strontium chromate, however, was classified as a carcinogen in humans, leading many in the paint industry to seek safer alternatives and the European Chemical Agency to enact strict regulations for its use (Hodges and others, 2010; European Chemical Agency, 2011). Other strontium compounds were used as catalysts to accelerate the drying of oils, paints, and printing inks (Brezinski and others, 2009).

The drug strontium ranelate, a strontium salt of ranelic acid, has been used to reduce the incidence of fractures in osteoporotic patients by promoting the uptake of calcium into bones (Nielsen, 2004). Medical trials demonstrated strontium ranelate drugs increased bone formation and decreased bone resorption, reducing both vertebral and nonvertebral fractures in patients with postmenopausal osteoporosis (Deeks and Dhillon, 2010). The isotope strontium-89 has been used successfully in medical trials for the treatment of pain associated with advanced metastatic cancer (Porter, 1994). Strontium chloride is used in toothpaste to treat tooth-sensitivity caused by temperature and pressure.

Strontium exhibits a high dielectric constant, making it an attractive material for use in wireless devices and memory chips. Strontium titanate is sometimes used as a substrate material for semiconductors and in some optical and piezoelectric applications. Research also was conducted into the use strontium in superconductors and radiation detectors. As the technology improves and costs decrease, high-tech industries are likely to consume more strontium (McCoy, 2009; McIntosh, 2009; Physorg, 2010; Walter, 2010; Singh, 2011).

Strontium oxide aluminate is used as a phosphorescent (glow-in-the-dark) pigment in applications such as emergency exit signs that glow brighter and longer than those using more-common photoluminescent pigments (Merit Lighting, LLC, 2008). Strontium phosphate is used in the manufacture of fluorescent lights, and the entire range of strontium chemicals is used in analytical chemistry laboratories.

Prices

Based on data published by the U.S. Census Bureau, the average customs unit value for celestite imported from Mexico was $45.41 per metric ton, a decrease of 3.6% compared with that of 2009. The average unit customs value of imported strontium carbonate was $0.71 per kilogram, an 8.9% increase from $0.65 per kilogram in 2009. In 2010, the unit value of imported strontium metal decreased to $5.80 per kilogram from $8.05 per kilogram. In 2010, the corresponding value for strontium nitrate was $1.33 per kilogram, which was 33% higher than that of 2009. Turkish f.o.b. prices for celestite (96% strontium sulfate) ranged from $90 per ton to $100 per ton in December 2010, essentially unchanged from the price range of December 2009 (Industrial Minerals, 2009, 2010).

Foreign Trade

With the changes in the domestic strontium market—strontium carbonate consumption for CRT production shifting to Asia and the continued consumption of strontium compounds for ceramics, glass, and pyrotechnics—strontium exports from and imports into the United States have become erratic from year to year. Adequate information to explain the variations is unavailable. Total strontium imports by gross weight were 20,900 t in 2010, a 17% decrease from those of 2009 but a 29% increase from those of 2008 (table 1). Total strontium exports by gross weight were 827 t in 2010—4.6% less than in 2008, but 7% more than in 2009.

Imports of celestite from Mexico were 5,400 t in 2009, a 63% decrease from the 14,600 t imported in 2009 and 17% more than those of 2008 (table 3). Imports of strontium metal and strontium nitrate increased from those of 2009 by 69% and 29%, respectively, spurred by increases in imports from China and Mexico. Strontium compounds imported from China, Germany, and Mexico represented about 99% of total strontium imports into the U.S. by gross weight, with Mexico representing 65%, Germany 21%, and China 14% of total imports.

Although strontium exports from the United States increased from 2009 to 2010, exports had been decreasing every year from 2006 to 2009, with 2010 exports 5% less than those of 2008. Exports to Belgium, the Republic of Korea, and Vietnam represented 67% of total strontium exports by gross weight (table 2).

World Review

Large deposits of high-grade celestite have been discovered throughout the world, but active mines are primarily in China, Mexico, and Spain. These countries represented 97% of total celestite produced in 2010. Turkey had been another leading celestite producer but has experienced significant declines in production in recent years, with no celestite production since 2008. Smaller operations are located in Argentina, Iran, Morocco, and Pakistan. Many large deposits are not economically feasible to mine owing to high levels of barium and calcium, impurities requiring energy-intensive and cost-prohibitive methods for separation. Most strontium producers require a minimum of 90% strontium sulfate content to achieve profitability. Hand sorting and some washing are all that are necessary at many strontium mines; a few operations use froth flotation, gravity separation, or other methods to beneficiate ore. Production facilities for strontium compounds and metal were located in Canada, China, Germany, Japan, the Republic of Korea, Mexico, and the United States, although the current status of some of these operations is unknown.

Owing to decreased demand for CRTs and increased competition for the Chinese market, the Montevive celestite mine in Granada, Spain, (operated by Bruno SA) closed in late 2009 after more than 50 years of operation. The Belgian chemical producer Solvay Minerales SA was the only remaining celestite producer in Spain (O'Driscoll, 2009). Spanish celestite production decreased significantly in 2009, but further production decreases did not materialize in 2010. Although, overall, the Spanish minerals industry suffered a 15% to 20% drop in demand in 2010, celestite production remained the same as in 2009 (Moores, 2010).

Outlook

Improved economic conditions worldwide could spur growth in demand for strontium carbonate in more traditional applications. Use of strontium by the ceramics, glass, and pyrotechnic industries is expected to continue, with solid demand for strontium used in ferrite magnets. With improvements in advanced applications, consumption of strontium in new end uses may increase.

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TABLE 1

SALIENT STRONTIUM STATISTICS[1]

(Metric tons of contained strontium and dollars per metric ton unless otherwise noted)[2]

	2006	2007	2008	2009	2010
United States:					
Production, strontium minerals	--	--	--	--	--
Imports for consumption:[3]					
Strontium compounds	8,860	8,550	9,420	5,860	8,640
Strontium minerals	671	541	2,030	6,420	2,370
Exports, compounds[3]	699	688	594	532	566
Apparent consumption[4]	8,830	8,400	10,900	11,800	10,400
Price, average value of mineral imports at port of exportation	64	67	64	47	45
World, production of celestite, gross weight	524,000	518,000	656,000	400,000 [r]	405,000 [e]

[e]Estimated. [r]Revised. -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] The strontium content of celestite is 43.88%, which was used to convert units of celestite.

[3] Source: U.S. Census Bureau.

[4] Production plus imports minus exports.

TABLE 2

U.S. EXPORTS OF STRONTIUM COMPOUNDS, BY COUNTRY[1]

	2009		2010	
	Gross weight (kilograms)	Value[2]	Gross weight (kilograms)	Value[2]
Strontium carbonate, precipitated:				
Austria	--	--	2,690	$2,550
Canada	30,900	$32,200	7,500	10,200
Germany	3,840	3,650	--	--
Japan	13,100	21,800	30,000	39,400
Mexico	102,000	41,100	73,100	45,800
Netherlands	6,320	6,000	--	--
Spain	--	--	7,530	7,150
United Kingdom	2,780	2,640	--	--
Total	159,000	107,000	121,000	105,000
Strontium oxide, hydroxide, peroxide:				
Argentina	--	--	25,100	13,800
Belgium	215,000	121,000	215,000	121,000
Brazil	--	--	21,600	11,900
Canada	--	--	62,600	30,100
Colombia	--	--	20,000	10,600
Germany	176,000	97,000	--	--
Israel	11,000	6,070	--	--
Japan	25,600	14,100	--	--
Korea, Republic of	102,000	56,100	264,000	148,000
Sweden	18,400	10,100	2,250	2,530
Switzerland	27,900	15,300	--	--
Taiwan	38,000	34,700	20,000	10,600
Trinidad and Tobago	--[r]	--[r]	--	--
Vietnam	--	--	76,000	46,400
Total	614,000[r]	355,000[r]	707,000	395,000

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship value.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 3

U.S. IMPORTS FOR CONSUMPTION OF STRONTIUM COMPOUNDS, BY COUNTRY[1]

	2009		2010	
	Gross weight (kilograms)	Value[2]	Gross weight (kilograms)	Value[2]
Celestite, Mexico	14,600,000	$690,000	5,400,000	$245,000
Strontium carbonate:				
China	600,000	693,000	2,380,000	2,320,000
Germany	1,240,000	703,000	4,290,000	2,880,000
Italy	20,400	124,000	14,000	82,300
Mexico	5,890,000	3,500,000	5,000,000	2,990,000
Spain	72,600	64,900	26,000	29,200
United Kingdom	25	9,720	10	4,430
Total	7,820,000	5,090,000	11,700,000	8,310,000
Strontium metal:				
China	20,200	149,000	118,000	682,000
Germany	--	--	21	3,500
Japan	30,400	71,200	--	--
Switzerland	19,500	344,000	--	--
Total	70,100	564,000	118,000	686,000
Strontium nitrate:				
Canada	1,700	5,700	--	--
China	93,600	115,000	231,000	273,000
France	--	--	1,600	16,100
Israel	--	--	9,600	9,070
Japan	58,000	178,000	181,000	1,540,000
Mexico	2,550,000	2,410,000	3,160,000	2,920,000
Spain	68,500	59,900	--	--
Total	2,770,000	2,770,000	3,580,000	4,760,000
Strontium oxide, hydroxide, peroxide:				
China	5,450	36,000	122,000	163,000
Japan	300	9,400	7,000	22,700
Korea, Republic of	974	5,370	--	--
Total	6,720	50,800	129,000	185,000

-- Zero.

[1] Data rounded to no more than three significant digits; may not add to totals shown.

[2] Free alongside ship value.

Source: U.S. Census Bureau.

TABLE 4

CELESTITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Argentina	19,822	4,904	14,910	8,169 [r]	7,000
China[e]	180,000	190,000	200,000	210,000	220,000
Iran[e, 4]	1,000	2,000	2,000	2,000	2,000
Mexico	125,000	125,000 [e]	96,902	37,601	31,429 [5]
Morocco[e]	2,700	2,700	2,700	2,600	2,500
Pakistan	1,466	1,476 [r]	1,500 [r, e]	1,600 [r, e]	1,600
Spain[e]	188,000	188,000	336,000 [5]	138,000 [5]	140,000 [p]
Turkey[e]	6,300	4,200	1,600	--	--
Total	524,000	518,000	656,000	400,000 [r]	405,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 11, 2011.

[3] In addition to the countries listed, Tajikistan was thought to produce celestite, but information was not available to make reliable estimates.

[4] Data are for year beginning March 21 of that stated.

[5] Reported figure.

SULFUR

By Lori E. Apodaca

Domestic survey data and tables were prepared by Rym Ferahtia, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, the global economy began to recover from the recession of 2008–09, which resulted in an increase in consumption and prices for sulfur. Demand for sulfur was strong in the phosphate sector because the fertilizer producers needed to restock their product inventories after operating at low production levels in 2009. In addition, phosphate fertilizer producers operated at high rates to keep up with increasing demand for fertilizers. Sulfur imports were up significantly compared with those in 2009 owing to the demand for sulfur in the production of fertilizers and industrial sectors.

The United States was second in world sulfur production following China. Elemental sulfur and byproduct sulfuric acid produced as a result of efforts to meet environmental requirements that limit atmospheric emissions of sulfur dioxide were the dominant sources of sulfur around the world.

Through its major derivative, sulfuric acid, sulfur ranks as one of the most important elements used as an industrial raw material and is of prime importance to every sector of the world's fertilizer and manufacturing industries. Sulfuric acid production is the major end use for sulfur, and consumption of sulfuric acid has been regarded as one of the best indexes of a nation's industrial development. More sulfuric acid is produced in the United States every year than any other inorganic chemical; 32.5 million metric tons (Mt), which is equivalent to about 10.6 Mt of elemental sulfur, was produced in 2010, about 12% more than that in 2009 (U.S. Census Bureau, 2011).

In 2010, domestic production of sulfur in all forms was slightly higher than in 2009; shipments of sulfur in all forms increased by about 3%. Elemental sulfur recovered at petroleum refineries was slightly higher than it was in 2009, and sulfur recovered from natural gas operations decreased by 4%. Producers' stocks decreased by 29%, representing about 2% of shipments. Byproduct sulfuric acid production and shipments increased by about 6%. Apparent consumption of sulfur in all forms increased by 19%. Imports of elemental sulfur and sulfuric acid combined increased by 72% and exports remained about the same. The average unit value in 2010 was about 40 times higher, resulting in the value of elemental sulfur shipments increasing by a factor of nearly 7 compared with the 2009 value of shipments. The total value of byproduct sulfuric acid shipments increased by about 6% (table 1).

Worldwide, compliance with environmental regulations has contributed to increased sulfur recovery; for 2010, global sulfur production increased slightly. Recovered elemental sulfur is produced primarily during the processing of natural gas and crude petroleum. Estimated worldwide production of native (naturally occurring elemental) sulfur increased by 23%. In the few countries where pyrites remain an important raw material for sulfuric acid production, sulfur production from pyrites was slightly lower.

Since 2005, between 82% and 83% of the world's sulfur production as elemental sulfur and byproduct sulfuric acid came from recovered sources. Some sources of sulfur were unspecified, which means that the material could have been, and likely was, elemental sulfur or byproduct sulfuric acid, raising the percentage of byproduct sulfur production to about 90% annually. The quantity of sulfur produced from recovered sources was dependent on the world demand for fuels, nonferrous metals, and petroleum products rather than for sulfur.

World sulfur consumption was estimated to have increased from that of 2009; typically, about 50% was used in fertilizer production, and the remainder, in myriad other industrial uses. World trade of elemental sulfur increased from the levels reported in 2009. Worldwide inventories of elemental sulfur were tight owing to the increased demand for sulfur, although stocks at remote operations remained high.

Legislation and Government Programs

In June, the U.S. Environmental Protection Agency (EPA) finalized the primary National Ambient Air Quality Standard (NAAQS) for sulfur dioxide (SO_2). The revised standard established a new 1-hour SO_2 standard at a level of 75 parts per billion. EPA also revoked its 24-hour and annual primary SO_2 standards, which were established in 1971. The rule likely would affect coal-burning utilities and copper and other nonferrous metal smelters that would need to reduce emissions under the new standard (U.S. Environmental Protection Agency, 2010, p. 2).

In July, the Governor of New York State signed a bill into law (S.1145–C) that limits sulfur in home heating oil. The bill limits the sulfur content of No. 2 heating oil for use in residential, commercial, or industrial heating applications to no more than 15 parts per million (ppm) starting in July 2012, down from the current range of 2,000 to 10,000 ppm. This is the same standard set by the EPA for diesel fuel (New York State Governor, 2010).

Production

Recovered Elemental Sulfur.—U.S. production statistics were collected on a monthly basis and published in the U.S. Geological Survey (USGS) monthly sulfur Mineral Industry Surveys. All 102 operations to which survey requests were sent responded; this represented 100% of the total production listed in table 1. In 2010, production was slightly higher than that of 2009, and shipments were about 3% higher. Increased price and demand for sulfur resulted in the value of shipments being more than six and a half times higher than of that of 2009. Accidents, technical problems, maintenance, and weather issues at a few refineries limited the amount of sulfur that could be recovered. For 2010, on average, U.S. petroleum refineries operated at

86.4% of capacity, a 4% increase from that of 2009 (U.S. Energy Information Administration, 2011c).

Recovered elemental sulfur, which is a nondiscretionary byproduct from petroleum-refining, natural-gas-processing, and coking plants, was produced primarily to comply with environmental regulations that were applicable directly to emissions from the processing facility or indirectly by restricting the sulfur content of the fuels sold or used by the facility. Recovered sulfur was produced by 34 companies at 102 plants in 26 States and 1 plant in the U.S. Virgin Islands. The size of the sulfur recovery operations varied greatly from plants producing more than 500,000 metric tons per year (t/yr) to others producing less than 500 t/yr. Of all the sulfur operations canvassed, 32 produced more than 100,000 metric tons (t) of elemental sulfur in 2009, 15 produced between 50,000 and 100,000 t, 36 produced between 10,000 and 50,000 t, and 20 plants produced less than 10,000 t. By source, 86% of recovered elemental sulfur production came from petroleum refineries or satellite plants that treated refinery gases and coking plants; the remainder was produced at natural-gas-treatment plants (table 3).

The leading producers of recovered sulfur, all with more than 500,000 t of sulfur production, in descending order of production, were Exxon Mobil Corp., Valero Energy Corp., ConocoPhillips Co. (including its joint venture with Encana Corp.), Chevron Corp., BP p.l.c., and Marathon Petroleum Corp. The 53 plants owned by these companies accounted for 67% of recovered sulfur output during the year. Recovered sulfur production by State and district is listed in tables 2 and 3.

In 2010, 6 of the 20 largest oil refineries in the world, in terms of crude processing capacity, were in the United States. In descending order of capacity, they were Exxon Mobil's Baytown, TX, and Baton Rouge, LA, refineries; Hovensa L.L.C.'s [Hess Corp.'s joint venture with Petróleos de Venezuela S.A. (PdVSA)] St. Croix, U.S. Virgin Islands, refinery; BP's Texas City, TX, refinery; Citgo Petroleum Corp.'s Lake Charles, LA, refinery; and Marathon's Garyville, LA, refinery (Oil & Gas Journal, 2010b). The capacity to process large quantities of crude oil does not necessarily mean that refineries recover large quantities of sulfur, but all these refineries were major producers of recovered sulfur. Sulfur production depends on installed sulfur recovery capacity as well as the types of crude oil that were refined at the specific refineries. Major refineries that process low-sulfur crude oils may have relatively low sulfur production. According to Oil & Gas Journal (2010a), the United States operated 20% of world refining capacity, but had almost 39% of sulfur recovery capacity at refineries.

According to data from the National Petrochemical & Refiners Association (2011, p. 3), U.S. refining capacity rose by more than 4% from 2004 through 2010 and by more than 7% from 2000 through 2010, without building any new refineries. In 2010, U.S. refinery capacity was 18 million barrels per day. Overall U.S. refinery capacity increased by 153,000 barrels per day (bbl/d) in 2010; reaching a 5-year high. Although this information did not specifically mention sulfur capacity expansion, any such expansions would likely include increased sulfur recovery facilities, probably proportionally higher than the increases in throughput capacity.

In June, PBF Energy Co. Ltd. completed its purchase of the Delaware City, DE, refinery from Valero at a cost of $200 million. The 211,000-bbl/d refinery was closed by Valero in late 2009 as a result of poor economic conditions. PBF began maintenance work at the refinery and planned to restart it in 2011(Sulphur, 2010j).

Western Refining Inc. idled its Yorktown, VA, refinery in September because of weak refining margins on the east coast. The company planned to continue operations at its products terminal and storage facility and supply the region with finished products. Restarting of the 70,800-bbl/d refinery was possible, if market conditions improved (Western Refining Inc., 2010).

During 2010, expansion and improvement projects were underway or in the planning stages at 11 refineries in the United States. In addition to increasing throughput capacity at the operations, upgrades were intended to increase the existing refineries' capability to process low-quality, high-sulfur crudes, such as those from Canadian oil sands, Saudi Arabia, and Venezuela. Oil sands producers were partners in some of the projects, as part of a strategy to ensure outlets for future oil sands production. One new Texas sulfur recovery plant was completed in 2010, but most were expected to be completed between 2011 and 2015 (Sulphur, 2011).

Byproduct Sulfuric Acid.—Sulfuric acid production at copper, lead, molybdenum, and zinc roasters and smelters accounted for about 9% of total domestic production of sulfur in all forms and totaled the equivalent of 791,000 t of elemental sulfur. The portion of total sulfur product represented by byproduct sulfuric acid increased and the total quantity produced increased by about 6% (table 4). Three acid plants operated in conjunction with copper smelters, and three were byproduct operations of lead, molybdenum, and zinc smelting and roasting operations. The three largest byproduct sulfuric acid plants, in terms of size and capacity, were associated with copper smelters and accounted for 89% of the byproduct sulfuric acid output. The copper producers—Asarco LLC, Kennecott Utah Copper Corp., and Freeport McMoRan Copper & Gold Inc.—each operated a sulfuric acid plant at its primary copper smelter.

Freeport McMoRan proceeded with its $150 million project to build a 1,450-metric-ton-per-day (t/d) sulfur-based sulfuric acid plant at its copper operation in Safford, AZ. The project had been put on hold in December 2008 as a result of the economic conditions in the copper industry and the downturn in the U.S. economy. The plant was expected to use sulfur brought by rail to a transport facility northwest of Stafford and then trucked to the plant. This plant was expected to use about 200,000 t/yr of sulfur (North America Sulphur Review, 2010). The project was expected to be completed within a year because much of the preliminary work had already begun (Sulphur, 2010i).

Consumption

Apparent domestic consumption of sulfur in all forms was 19% higher than that of 2009 (table 5). Of the sulfur consumed, 68% was obtained from domestic sources as elemental sulfur (61%) and byproduct acid (7%) compared with 79% in 2009, 64% in 2008, 69% in 2007, and 69% in 2006. The remaining

32% was supplied by imports of recovered elemental sulfur (26%) and sulfuric acid (6%). The USGS collected end-use data on sulfur and sulfuric acid according to the standard industrial classification of industrial activities (table 6).

Sulfur differs from most other major mineral commodities in that its primary use is as a chemical reagent rather than as a component of a finished product. This use generally requires that it be converted to an intermediate chemical product prior to its initial use by industry. The leading sulfur end use, sulfuric acid, represented 70% of reported consumption with an identified end use. Although reported as elemental sulfur consumption in table 6, it is reasonable to assume that nearly all the sulfur consumption reportedly used in petroleum refining was first converted to sulfuric acid, bringing sulfur used to produce sulfuric acid to 90% of the total sulfur consumption. Some identified sulfur end uses were included in the "Unidentified" category because these data were proprietary. A significant portion of the sulfur in the "Unidentified" category may have been shipped to sulfuric acid producers or exported, although data to support such assumptions were not available.

Because of its desirable properties, sulfuric acid retained its position as the most universally used mineral acid and the most produced and consumed inorganic chemical, by volume. Data based on USGS surveys of sulfur and sulfuric acid producers showed that reported U.S. consumption of sulfur in sulfuric acid (100% basis) decreased by 10%, and total reported sulfur consumption decreased by 10%. These reported decreases in consumption can be attributed to the 9% decrease in petroleum refining and decreases in other chemical products. Reported consumption figures do not correlate with calculated apparent consumption owing to reporting errors and possible double counting in some data categories. These data are considered independently from apparent consumption as an indication of market shares rather than actual consumption totals.

Agriculture was the leading sulfur-consuming industry; consumption in this end use increased slightly to 6.71 Mt compared with 6.65 Mt in 2009 with an increase only for phosphatic fertilizers. Based on export data reported by the U.S. Census Bureau, the estimated quantity of sulfur needed to manufacture exported phosphatic fertilizers decreased by about 7% to 4.2 Mt. More than 50% of domestic fertilizer production typically is exported; in 2010 about 50% was exported.

The second ranked end use for sulfur was in petroleum refining and other petroleum and coal products. Producers of sulfur and sulfuric acid reported that the consumption of sulfur in that end use decreased by 9% from that of 2009. Demand for sulfuric acid in copper ore leaching, which was the third ranked end use, increased by 10%.

The U.S. Census Bureau (2011) also reported that 2.1 Mt of sulfuric acid was produced as a result of recycling spent and contaminated acid from petroleum alkylation and other processes. Two types of companies recycle this material—companies that produce acid for consumption in their own operations and also recycle their own spent acid and companies that provide acid regeneration services to sulfuric acid users. The petroleum refining industry was thought to be the leading source and consumer of recycled acid for use in its alkylation process.

Stocks

Yearend inventories held by recovered elemental sulfur producers decreased to 164,000 t, 29% less than those of 2009 (table 1). Based on apparent consumption of all forms of sulfur, combined yearend stocks amounted to about a 5-day supply, compared with a 9-day supply in 2009. Final stocks in 2010 represented 3% of the quantity held in inventories at the end of 1976, when sulfur stocks peaked at 5.56 Mt, a 7.4-month supply at that time (Shelton, 1978, p. 1296). When the United States mined large quantities of sulfur, as in 1976, mining companies had the capacity to store large quantities. When mining ceased in 2000, storage capacity declined significantly. Since that time, stocks have been relatively low because recovered sulfur producers have very little room for stocks.

Prices

Increased demand for sulfur during 2010 resulted in higher prices. Based on total shipments and value reported to the USGS, the average value of shipments for all elemental sulfur was estimated to be $70.48 per metric ton, which was about 40 times greater than that of 2009. The increased value reported by producers correlated with the trends in prices recorded in trade publications.

The contract prices for elemental sulfur at terminals in Tampa, FL, which are reported weekly in Green Markets, began the year at $27 per ton. In February, prices increased to $82 per ton. In May, prices again increased to $132 per ton, but decreased in August to $86 per ton. Prices remained at that level until end of October, when they increased to $145 per ton. The Tampa contract price remained at that level through the end of 2010, and additional price increases were expected in 2011.

Prices vary greatly on a regional basis. Tampa prices were usually the highest reported in the United States because of the large sulfur demand in the central Florida area. During 2010, U.S. West Coast prices varied from $0 per ton to $90 per ton. Nearly all the sulfur produced in some regions, such as the West Coast, is processed at forming plants, incurring substantial costs to make solid sulfur in acceptable forms to be shipped overseas. The majority of West Coast sulfur was shipped overseas. World sulfur prices generally were higher than domestic prices in 2010.

Even though prices vary by location, provider, and type, the Abu Dhabi National Oil Co.'s (ADNOC) price is recognized as an indicator of world sulfur price trends. In 2010, the ADNOC contract 2010 price averaged nearly $150 per ton, with the lowest price of $65 per ton in July and the highest price of $210 per ton in March (North America Sulphur Review, 2011b).

Foreign Trade

Strong domestic demand during much of the year resulted in exports from the United States, including the U.S. Virgin Islands, remained about the same in quantity but increased by 108% in value compared with those of 2009. The average unit value of export material was $119 per ton, an increase of 105% from $58 in 2009 (table 7). The leading destination for this material was Brazil, followed by, in descending quantity, China, Mexico, and Canada. Export facilities on the Gulf Coast that began shipping in 2006 have become a significant source for exported sulfur. Exports from the West Coast were 710,000 t, or 49% of total U.S. exports. Exports from the Gulf Coast were 570,000 t, or 39% of the U.S. total.

The United States continued to be a net importer of sulfur. Imports of elemental sulfur exceeded exports by about 1.5 Mt. Recovered elemental sulfur from Canada, Mexico, and Venezuela delivered to U.S. terminals and consumers in the liquid phase furnished almost 93% of U.S. sulfur import requirements. Total elemental sulfur imports were 74% greater in quantity than those of 2009, and higher prices for imported material resulted in the value being about three times that of 2009. Imports from Canada, mostly by rail, were estimated to be 62% higher than those of 2009, waterborne shipments from Mexico were twice as high, and waterborne imports from Venezuela were estimated to have decreased by 71%. Canada was the source of an estimated 79% of elemental sulfur imports, and Mexico supplied 13% (table 9).

In addition to elemental sulfur, the United States had significant trade in sulfuric acid. Sulfuric acid exports were 15% lower than those of 2009 (table 8). Acid imports were about 10 times exports (table 10). Canada and Mexico were the sources of 64% of acid imported into the United States, most of which was probably byproduct acid from smelters. Shipments from Canada and some from Mexico came by rail, and the remainder of imports came primarily by ship from Asia and Europe. The tonnage of sulfuric acid imports was about 67% greater than that of 2009, and the value of imported sulfuric acid decreased by about 5%.

World Review

The world sulfur industry remained divided into two sectors—discretionary and nondiscretionary. In the discretionary sector, the mining of sulfur or pyrites is the sole objective; this voluntary production of either sulfur or pyrites (mostly naturally occurring iron sulfide) is based on the orderly mining of discrete deposits, with the objective of obtaining as nearly a complete recovery of the resource as economic conditions permit. In the nondiscretionary sector, sulfur or sulfuric acid is recovered as an involuntary byproduct; the quantity of output is subject to demand for the primary product and environmental regulations that limit atmospheric emissions of sulfur compounds irrespective of sulfur demand. Discretionary sources, once the primary sources of sulfur in all forms, represented 10% of the sulfur produced in all forms worldwide in 2010 (table 11).

Poland was the only country that produced more than 500,000 t of native sulfur by using either the Frasch process or conventional mining methods (table 11). The Frasch process is the term for hot-water mining of native sulfur associated with the caprock of salt domes and in sedimentary deposits; in this mining method, the native sulfur is melted underground with superheated water and brought to the surface by compressed air. The United States, where the Frasch process was developed early in the 20th century, was the leading producer of Frasch sulfur until 2000. Small quantities of native sulfur were produced in Asia, Europe, and South America. The importance of pyrites to the world sulfur supply has significantly decreased; China was the only country of the top producers whose primary sulfur source was pyrites. China produced 89% of world pyrite production.

Of the 27 countries listed in table 11 that produced more than 500,000 t of sulfur, 16 obtained the majority of their production as recovered elemental sulfur. These 27 countries produced 94% of the total sulfur produced worldwide. In 2010, about 31 Mt of elemental sulfur was traded globally. The leading exporters were, in decreasing order of tonnage, Canada, Russia, Kazakhstan, Saudi Arabia, Abu Dhabi, the United States, Japan, Iran, and Qatar, all with more than 1 Mt of exports. The leading importer was China, by far, followed by, in decreasing order of tonnage, Morocco, the United States, Tunisia, Brazil, and India. All of the top importing countries had large phosphate fertilizer industries (International Fertilizer Industry Association, 2011).

Increased demand combined with lower than projected supply resulted in a balance between consumption and supply in 2010. Prices were lowest at the beginning of 2010 and increased toward the end of 2010. International prices for 2010 averaged higher than those in the United States. Sulfur imports increased in some of the main sulfur consuming countries, except China whose imports in 2009 exceeded demand. China had stock carryovers into 2010.

Native sulfur production, including production of Frasch sulfur at Poland's last operating mine, was about 23% higher than that of 2009. Recovered elemental sulfur production increased slightly and byproduct sulfuric acid production increased by about 6% compared with those of 2009. Globally, production of sulfur from pyrites decreased slightly. Pyrites are a less attractive alternative to elemental sulfur for sulfuric acid production. The environmental remediation costs of mining pyrites are onerous, and additional costs are incurred when using this less environmentally friendly raw material to produce sulfuric acid.

Canada.—Ranked third in the world in sulfur production, Canada was the leading sulfur and sulfuric acid exporter. In 2010, sulfur production in Canada was 3% lower than it was in 2009. About two-thirds of Canadian sulfur is recovered at natural gas and oil sands operations in Alberta, with some recovered from gas in British Columbia and from oil refineries in other parts of the country. Sulfur production from natural gas processing declined by 7% in 2010, and production from oil sands was slightly higher in 2010 than in 2009 (North America Sulphur Review, 2011a).

Canada's sulfur production was expected to remain stable over the medium term and may increase during the long term as a result of expanded oil sands production. Sulfur production from natural gas was expected to decline as natural gas reserves decrease. Significant increases in production from oil sands operations and minor increases at refineries were expected. Canada was likely to remain a leader in world sulfur production. Byproduct acid production was expected to remain relatively stable (Stone, 2010).

A report from Alberta's Energy Resources Conservation Board (ERCB) published in 2011 showed that sulfur emissions in 2010 from Alberta's natural gas processing plants declined by 59% from levels in 2000 and 1% from those of 2009. Sulfur emissions declined as the result of improved sulfur recovery technology at the plants and because gas production declined as resources became depleted. Although sulfur recovery increased as a percentage of gas processing, total sulfur recovered declined during the same period because of lower gas processing volumes (Energy Resources Conservation Board, 2011, p. 6).

An estimated 400,000 t of sulfur was added to Canada's stockpiles in 2010. Stocks increased to about 11.9 Mt in Alberta in 2010 (North America Sulphur Review, 2011c). More than 8 Mt of the sulfur stocks was stored at Syncrude Canada Ltd.'s Fort McMurray, Alberta, oil sands operation. Fort McMurray is so remote that transporting the sulfur to market is extremely difficult and expensive (Stone, 2010).

Chile.—Outotec Oyj (Finland) signed a contract with Corporación Nacional Del Cobré de Chile (Codelco) to design and deliver a copper concentrate roasting plant, gas cleaning system, and sulfuric acid plant for Coldelco's new Mino Ministro Hales Mine close to Calama, in northern Chile. The $160 million plant would treat up to 555,000 t/yr of copper concentrate and produce approximately 250,000 t/yr of sulfuric acid. The plant was expected to be commissioned by 2012 (Sulphur, 2010a).

China.—China was the leading producer of sulfur in all forms. It also was the world's leading producer of pyrites, with about 46% of its sulfur in all forms coming from that source. The country was the leading sulfur importer, with 10.1 Mt in 2010 (International Fertilizer Industry Association, 2011). Imports represented 76% of elemental sulfur consumption in China, with the Middle East as the leading source of the imports, followed by Canada. Fertilizer production consumed about three-quarters of the sulfuric acid produced in China.

In December 2009, the Chinese Government released its 2010 tariff rates for many phosphate fertilizers to discourage exports during periods of high domestic demand. The surcharge for the phosphate fertilizers would be 110% during January to May and October to December, and 7% during June to September (Fertilizer Week America, 2009). The export tariff rates were expected to reduce buying activity by China, the largest sulfur market, and reduce prices. However, the price of sulfur was not affected (North America Sulphur Review, 2011b).

In China, 70% of electricity is generated at coal-fired powerplants that emit significantly more sulfur dioxide proportionally than powerplants in Western countries. Only about 14% of the Chinese powerplants have desulfurization apparatus, and of these, not all are fully operational. Industry experts estimated that China emitted 25 Mt of sulfur dioxide from powerplants in 2008, with expectations for this to increase as electricity requirements and capacity increased. Sulfur recovery from implementing clean coal technology in China could result in the recovery of at least some of this sulfur (Sulphur, 2008). China has begun to build more efficient, less polluting coal-fired powerplants.

India.—Essar Oil Ltd. was to expand capacity at its Vadinar refinery in Gujarat to 360,000 bbl/d from 210,000 bbl/d at a cost of $1.73 billion. Sulfur production from the refinery was expected to increase to 480,000 to 540,000 t/yr (Sulphur, 2010b).

Noraz Morarji Ltd. received approval from the Government of India to build a $15.3 million sulfuric acid, downstream chemicals, and boron products plant at Dahej. The plant would have the capacity to produce 130,000 t/yr of sulfuric acid, oleum, and liquid sulfur trioxide, and 24,000 t/yr of boron products (Sulphur, 2010c).

Jordan.—Jordan Phosphate Mines Co. signed a $625 million contract with SNC-Lavalin Group to construct a plant to produce 1,500 t/d of phosphoric acid and 4,500 t/d [1.5 million metric tons per year (Mt/yr)] of sulfuric acid. Construction of the project, in El Eshidiya, began in 2010 and was expected to be completed by 2012 (Sulphur, 2010d).

Kazakhstan.—Kazphosphate began construction of a 600,000-t/yr sulfuric acid plant at Taraz city in southern Kazakhstan. The $57 million project was expected to be completed by 2012 (Sulphur, 2010e).

Mexico.—Mexichem S.A.B. de C.V. reopened the Jaltipan sulfur mine in Veracruz State in May. The Frasch sulfur mine had been closed in 1992, although salt production continued at the site. Mexichem planned to operate the Jaltipan mine at a capacity of 210,000 t/yr sulfur. The Jaltipan salt and sulfur dome had proven reserves of 10 Mt of sulfur (Sulphur, 2010f). Sulfur production data for 2010 were not available.

Outlook

Since 2000, recovered sulfur production in the United States has been relatively stable, averaging about 8.6 Mt/yr, but significant increases were expected in upcoming years as expansions, upgrades, and new facilities at existing refineries were completed. The expansions were enabling refiners to increase throughput of crude oil and to process higher sulfur crude oils; additional sulfur production will be a result of refinery upgrades. Projects that had been announced before or during 2010 had the potential to add sulfur recovery capacity of about 20 Mt/yr by 2015, if all were completed on proposed schedules (Sulphur, 2011). In general, production from natural gas operations was expected to increase from that of 2010 as more natural gas is recovered from shale formations, horizontal drilling, and hydraulic fracturing. More efficient, cost-effective drilling techniques, primarily in shale formations, will be important for U.S. natural gas production (U.S. Energy Information Administration, 2011b).

Worldwide recovered sulfur output was expected to increase significantly. In 2009 and 2010, production of sulfur nearly satisfy demand, but severe sulfur surpluses were expected beginning in 2011, accelerating thereafter as a result of increased production, especially from oil sands in Canada, natural gas in the Middle East, expanded oil and gas operations in Kazakhstan, and heavy-oil processors in Venezuela.

Additional production increases were expected to come from Russia's increase in sulfur recovery from natural gas and Asia's improved sulfur recovery at oil refineries and new development of sour gas deposits. Refineries in developing countries were expected to improve environmental protection measures and, in the future, eventually approach the environmental standards of plants in Japan, North America, and Western Europe. Higher sulfur recovery likely will result from a number of factors, including higher refining rates, higher sulfur content in crude oil, lower allowable sulfur content in finished fuels, and reduced sulfur emissions mandated by regulations.

World consumption of natural gas was expected to maintain strong growth, and sulfur recovery from that sector likely will continue to increase. Natural gas continued to be the fuel of choice in many regions of the world in the electric power and industrial sectors, in part because of its lower carbon intensity compared with coal and oil, which makes it an attractive fuel source in countries where governments are implementing policies to reduce greenhouse gas emissions. Some of the future gas production, however, is expected to come from unconventional natural gas resources such as tight gas, shale gas, and coal bed methane (U.S. Energy Administration, 2011a, p. 43–44). Use of unconventional gas sources will certainly affect the sulfur supply outlook for the future as these gases have low sulfur content.

Domestic byproduct sulfuric acid production may fluctuate somewhat as the copper industry reacts to market conditions and varying prices by adjusting output at operating smelters. Worldwide, the outlook for byproduct acid was more predictable. Because copper production costs in some countries are lower than in the United States, acid production from those countries has increased, and continued increases are likely. Many copper producers have installed more efficient sulfuric acid plants to limit sulfur dioxide emissions at new and existing smelters. Byproduct sulfuric acid production was expected to increase to about 70 Mt in 2014 from about 60 Mt in 2009 (Sulphur, 2005). Worldwide, sulfur emissions at nonferrous smelters declined as a result of improved sulfur recovery; increased byproduct acid production is likely to become more a function of metal demand than a function of improved recovery technology. Smelter production in the United States has decreased by 40% since 2000; during the same period, Chinese smelter acid production has more than doubled. Additional smelter capacity was expected in Chile, India, Kazakhstan, and Peru (Sulphur, 2010g).

Frasch sulfur and pyrites production, however, has little chance of significant long-term increases. In 2010, Frasch sulfur production remained the same as that of 2009. Because of the continued increase in elemental sulfur recovery for environmental reasons rather than markets, discretionary sulfur has become increasingly less important as demonstrated by the decline of the Frasch sulfur industry. The Frasch process has become the high-cost process for sulfur production. The only potential increase in Frasch production is from Mexichem's Jaltipan sulfur mine. Pyrites, with significant direct production costs, is an even higher cost raw material for sulfuric acid production when the environmental aspects are considered. Discretionary sulfur output is likely to continue a steady decline. The decreases likely will be pronounced when large operations are closed outright for economic reasons, as was the case in 2000 and 2001.

For the long term, sulfur and sulfuric acid likely will continue to be important in agricultural and industrial applications. Because sulfuric acid consumption for phosphate fertilizer production was expected to increase at a lower rate than for some other uses, phosphate fertilizer may become less dominant, but is expected to remain the leading end use. Ore leaching likely will be the largest area of sulfur consumption growth.

From year to year, however, the use of sulfur directly or in compounds as fertilizer likely will continue to be dependent on agricultural economies and vary according to economic conditions. If widespread use of plant nutrient sulfur is adopted, then sulfur consumption in that application could increase significantly; thus far, however, growth has been slow. Expansions of phosphate fertilizer production were expected to be constructed in 11 countries; facilities were planned in Africa, Asia, Latin America, and Kazakhstan (Heffer and Prud'homme, 2011). Overall, one-half of all sulfur consumption (in all forms) is used for phosphate fertilizer production.

Industrial sulfur consumption has some prospects for growth, but not enough to consume all projected surplus. Solvent extraction-electrowinning copper projects that consume large quantities of sulfur are under development in Chile, China, India, Kazakhstan, and Peru during the next few years. Smelter acid represents almost one-third of sulfuric acid production (Sulphur, 2010g).

Unless less traditional uses for elemental sulfur increase significantly, the oversupply situation will result in tremendous stockpiles accumulating around the world. In the 1970s and 1980s, research was conducted that showed the effectiveness of sulfur in several construction uses that held the promise of consuming huge quantities of sulfur in sulfur-extended asphalt and sulfur concretes. In many instances, these materials were found to be superior to the more conventional products, but their use so far has been very limited. Concrete made with sulfur is more resistant to acid and saltwater; the manufacturing process lowers CO_2 emissions and does not require water to manufacture. However, when sulfur prices are high, sulfur is less attractive for unconventional applications where low-cost raw materials are an important factor. In 2010, the Middle East had the most active interest in the potential use of sulfur as a binder or extender for high performance concrete and asphalt mixture (Sulphur, 2010h).

Although periods of tight supplies may take place periodically, the long-term worldwide oversupply situation is likely to continue. Unless measures are taken to use more sulfur, either voluntarily or through government mandate, large quantities of excess sulfur could be amassed in many areas of the world, including the United States.

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TABLE 1
SALIENT SULFUR STATISTICS[1]

(Thousand metric tons of sulfur content and thousand dollars unless otherwise specified)

	2006	2007	2008	2009	2010
United States:					
Quantity:					
Production:					
Recovered[2]	8,390	8,280	8,550	8,190	8,290
Other	674	817	753	749	791
Total[e]	9,060	9,100	9,300	8,940	9,080
Shipments:					
Recovered[2]	8,290	8,310	8,530	8,110	8,350
Other	674	817	753	749	791
Total	8,960	9,130	9,280	8,860	9,140
Exports:					
Elemental[3]	635	922	953	1,430	1,450
Sulfuric acid	81	110	86	83	71
Imports:					
Elemental[e]	2,950	2,930	3,000	1,700	2,950
Sulfuric acid	802	857	1,690	413	690
Consumption, all forms[4]	12,000	11,900	12,900	9,460	11,300
Stocks, December 31, producer, recovered	221	187	211	232	167
Value:					
Shipments, free on board (f.o.b.) mine or plant:					
Recovered[e, 2]	272,000	303,000	2,250,000	14,000	586,000
Other	64,700	45,200	110,000	87,500[r]	92,400
Total	337,000	349,000	2,360,000	101,000[r]	678,000
Exports, elemental[5]	437,000	84,800	272,000	82,200	171,000
Imports, elemental	70,400	79,400	753,000	54,100	214,000
Price, elemental, f.o.b. mine or plant[e] dollars per metric ton	32.85	36.49	264.04	1.73	70.16
World, production, all forms (including pyrites)	67,000[r]	67,600[r]	68,100[r]	66,600[r]	68,100

[e]Estimated. [r]Revised.

[1]Data are rounded to no more than three significant digits except prices; may not add to totals shown.

[2]Includes U.S. Virgin Islands.

[3]Includes exports from the U.S. Virgin Islands to foreign countries.

[4]Consumption is calculated as shipments minus exports plus imports.

[5]Includes value of exports from the U.S.Virgin Islands to foreign countries

TABLE 2
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES, BY STATE[1]

(Thousand metric tons and thousand dollars)

	2009			2010		
		Shipments			Shipments	
State	Production	Quantity	Value^e	Production	Quantity	Value^e
Alabama	268	264	-4,490	259	258	25,100
California	1,010	1,000	4,280	1,050	1,100	60,800
Illinois	457	457	-1,160	458	457	28,500
Louisiana	1,330	1,370	10,300	1,260	1,240	89,400
Michigan and Minnesota	35	35	-679	W	W	W
New Mexico	25	25	388	25	25	734
Ohio	133	133	460	126	125	13,000
Texas	2,900	2,860	4,450	3,100	3,100	233,000
Washington	125	126	-284	139	138	5,890
Wyoming	656	668	3,600	624	625	29,100
Other[2]	1,250	1,170	-2,880	1,250	1,290	99,700
Total	8,190	8,110	14,000	8,290	8,350	586,000

[e] Estimated. W Withheld to avoid disclosing company proprietary data; included in "Other."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes Arkansas, Colorado, Delaware, Florida, Indiana, Kansas, Kentucky, Mississippi, Montana, New Jersey, North Dakota, Pennsylvania, Utah, Virginia, Wisconsin, and the U.S. Virgin Islands.

TABLE 3
RECOVERED SULFUR PRODUCED AND SHIPPED IN THE UNITED STATES, BY PETROLEUM ADMINISTRATION FOR DEFENSE (PAD) DISTRICT[1]

(Thousand metric tons)

	2009		2010	
District and source	Production	Shipments	Production	Shipments
PAD 1:				
Petroleum and coke	168	166	136	136
Natural gas	13	13	13	13
Total	181	179	150	149
PAD 2:				
Petroleum and coke	945	932	1,010	1,020
Natural gas	28	28	23	23
Total	973	960	1,040	1,040
PAD 3:[2]				
Petroleum and coke	4,580	4,580	4,680	4,660
Natural gas	546	485	486	509
Total	5,120	5,060	5,160	5,170
PAD 4 and 5:				
Petroleum and coke	1,280	1,270	1,290	1,350
Natural gas	627	638	647	648
Total	1,910	1,910	1,940	2,000
Grand total	8,190	8,110	8,290	8,350
Of which:				
Petroleum and coke	6,970	6,950	7,120	7,150
Natural gas	1,220	1,160	1,170	1,190

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes the U.S. Virgin Islands.

TABLE 4
BYPRODUCT SULFURIC ACID PRODUCED IN THE UNITED STATES [1]

(Thousand metric tons of sulfur content and thousand dollars)

Type of plant	2009	2010
Copper[2]	671	704
Zinc, lead, and molybdenum[3]	79	87
Total:		
Quantity	749	791
Value	87,500 [r]	92,400

[r] Revised.

[1] May include acid produced from imported raw materials. Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes acid made from pyrites concentrates.

[3] Excludes acid made from native sulfur.

TABLE 5
CONSUMPTION OF SULFUR IN THE UNITED STATES[1]

(Thousand metric tons of sulfur content)

	2009	2010
Elemental sulfur:		
Shipments[2]	8,110	8,350
Exports	1,430	1,450
Imports[e]	1,700	2,950
Total	8,380	9,850
Byproduct sulfuric acid:		
Shipments	749	791
Exports[3]	83	71
Imports[3]	413	690
Total	1,080	1,410
Grand total	9,460	11,300

[e] Estimated.

[1] Crude sulfur or sulfur content. Data are rounded to no more than three significant digits; may not add to totals shown. Consumption is calculated as shipments minus exports plus imports.

[2] Includes the U.S. Virgin Islands.

[3] May include sulfuric acid other than byproduct.

TABLE 6

SULFUR AND SULFURIC ACID SOLD OR USED IN THE UNITED STATES, BY END USE[1]

(Thousand metric tons of sulfur content)

		Elemental sulfur[2]		Sulfuric acid (sulfur equivalent)		Total	
SIC[3]	End use	2009	2010	2009	2010	2009	2010
102	Copper ores	--	--	363	400	363	400
1094	Uranium and vanadium ores	--	--	2	--	2	--
10	Other ores	--	--	112	62	112	62
26, 261	Pulpmills and paper products	W	W	188	79	188	79
28, 285, 286, 2816	Inorganic pigments, paints, and allied products; industrial organic chemicals; other chemical products[4]	W	W	286	31	286	31
281	Other inorganic chemicals	W[r]	W	99	57	99[r]	57
282, 2822	Synthetic rubber and other plastic materials and synthetics	W	W	64	6	64	6
2823	Cellulosic fibers including rayon	--	--	7	--	7	--
284	Soaps and detergents	--[r]	--	3	2	3	2
286	Industrial organic chemicals	--	--	36	9	36	9
2873	Nitrogenous fertilizers	--	--	161	16	161	16
2874	Phosphatic fertilizers	--	--	5,430	5,700	5,430	5,700
2879	Pesticides	--	--	9	12	9	12
287	Other agricultural chemicals	1,000	952	44	30	1,050	982
2892	Explosives	--	--	10	11	10	11
2899	Water-treating compounds	--	--	64	26	64	26
28	Other chemical products	--	--	250	21	250	21
29, 291	Petroleum refining and other petroleum and coal products	2,360	2,050	283	368	2,650	2,410
331	Steel pickling	--	--	8	11	8	11
33	Other primary metals	--	--	5	--	5	--
3691	Storage batteries (acid)	--	--	28	30	28	30
	Exported sulfuric acid	--	--	197	3	197	3
	Total identified	3,370	3,000	7,650	6,880	11,000	9,880
	Unidentified	489	482	96[r]	96	585	578
	Grand total	3,860	3,480	7,740	6,980	11,600	10,500

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Unidentified." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Does not include elemental sulfur used for production of sulfuric acid.

[3] Standard industrial classification.

[4] No elemental sulfur was used in inorganic pigments, paints, and allied products.

TABLE 7

U.S. EXPORTS OF ELEMENTAL SULFUR, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

	2009		2010	
Country	Quantity	Value	Quantity	Value
Brazil	383	15,600	632	58,000
Canada	29	5,730	58	8,620
China	731	39,800	317	48,900
Mexico	127	8,030	169	22,100
Morocco	33	1,610	34	2,890
Other	122	11,400	235	30,800
Total	1,430	82,200	1,450	171,000

[1] Includes exports from the U.S. Virgin Islands. Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 8

U.S. EXPORTS OF SULFURIC ACID (100% H_2SO_4), BY COUNTRY[1]

	2009		2010	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Canada	212,000	$14,300	155,000	$12,500
China	2,750	371	4,670	1,060
Dominican Republic	649	149	2,530	363
El Salvador	469	74	894	112
Germany	494	102	31	69
Greece	505	60	331	38
Hong Kong	21	57	46	93
Ireland	1,180	1,500	956	845
Israel	2,680	2,340	1,760	2,270
Korea, Republic of	79	30	46	23
Mexico	3,810	1,150	14,700	2,390
Netherlands Antilles	3,040	539	2,000	2,000
Nigeria	1	9	35	4
Philippines	469	313	1,540	661
Poland	825	94	947	108
Singapore	66	143	2,180	591
Taiwan	843	205	138	161
Thailand	463	95	693	88
Trinidad and Tobago	4,760	543	10,500	858
Venezuela	16,400	1,070	8,440	577
Other	2,230	767	8,100	1,590
Total	254,000	23,900	215,000	26,400

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS OF ELEMENTAL SULFUR, BY COUNTRY[1]

(Thousand metric tons and thousand dollars)

Country	2009		2010	
	Quantity	Value[2]	Quantity	Value[2]
Canada	1,430	45,800	2,320 e	122,000
Mexico	125	2,540	378	37,400
Venezuela	140	2,400	41	4,200
Other	6	3,390	211	50,200
Total	1,700	54,100	2,950 e	214,000

[e] Estimated.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Declared customs valuation.

Source: U.S. Census Bureau and ICIS PentaSul North American Sulphur Service as adjusted by the U.S. Geological Survey.

TABLE 10
U.S. IMPORTS OF SULFURIC ACID (100% H_2SO_4), BY COUNTRY[1]

Country	2009		2010	
	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
Bulgaria	29,100	$481	--	--
Canada	821,000	118,000	1,150,000	$79,100
China	392	386	91,000	8,880
Egypt	--	--	11,500	1,560
Finland	39,300	4,040	1,000	657
Germany	--	--	133,000	3,920
Japan	20,000	477	60,900	3,640
Korea, Republic of	37,000	4,160	17,000	2,040
Mexico	108,000	4,750	199,000	11,100
Peru	66,700	2,300	--	--
Poland	30,200	434	79,300	4,200
Sweden	15,600	742	27,600	696
Other	98,200	10,300	336,000	23,100
Total	1,260,000	146,000	2,110,000	139,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Declared cost, insurance, and freight paid by shipper valuation.

Source: U.S. Census Bureau.

TABLE 11

SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE[1, 2]

(Thousand metric tons)

Country and source[3]	2006	2007	2008	2009	2010
Australia, byproduct:[e]					
Metallurgy	880	890	880	870	880
Petroleum	58	60	58	60	60
Total	938	950	938	930	940
Brazil:					
Frasch	21	22	22 [e]	22 [e]	22 [e]
Byproduct:					
Metallurgy	298	322	322	322	322 [e]
Petroleum	117	136	136	136	136
Total	436	480	480	480	480
Canada, byproduct:					
Metallurgy	1,176	1,167	1,148 [r]	890 [e]	900 [e]
Natural gas, petroleum, oil sands	7,906	7,622	7,008 [r]	6,577	6,355
Total	9,082	8,789	8,156 [r]	7,467	7,255
Chile, byproduct, metallurgy	1,641	1,569	1,573	1,653 [r]	1,676
China:[e]					
Elemental	950	960	960	1,000	1,100
Pyrites	3,810	4,200	4,300	4,370	4,400
Byproduct, metallurgy	3,000	3,300	3,350	4,000	4,100
Total	7,760	8,460	8,610	9,370	9,600
Finland:[e]					
Pyrites	250	250	250	250	225
Byproduct:					
Metallurgy	300	300	300	300	300
Petroleum	65	65	65	65	65
Total	615	615	615	615	590
France, byproduct:[e]					
Natural gas and petroleum	616 [4]	606 [4]	605	605	605
Unspecified	750	700	700	700	700
Total	1,366 [4]	1,306 [4]	1,310	1,310	1,310
Germany, byproduct:					
Metallurgy	2,437 [r]	2,454 [r]	2,458 [r]	2,137 [r]	2,458
Natural gas and petroleum	1,686	1,637	1,709	1,623	1,447
Total	4,124 [r]	4,091 [r]	4,167 [r]	3,760 [r]	3,905
India:[e]					
Pyrites	32	32	32	32	31
Byproduct:					
Metallurgy	600	590	600	590	600
Natural gas and petroleum	540	530	540	530	540
Total	1,170	1,150	1,170	1,150	1,170
Iran, byproduct:[e]					
Metallurgy	65	70	70	70	80
Natural gas and petroleum	1,400	1,500	1,500	1,500	1,700
Total	1,470	1,570	1,570	1,570	1,780

See footnotes at end of table.

TABLE 11—Continued

SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE[1,2]

(Thousand metric tons)

Country and source[3]	2006	2007	2008	2009	2010
Italy, byproduct:[e]					
Metallurgy	90	90	90	90	90
Petroleum	650	650	650	650	650
Total	740	740	740	740	740
Japan, byproduct:					
Metallurgy	1,343	1,250[e]	1,300	1,350	1,400
Petroleum	1,950	1,966	2,034	1,864[r]	1,892
Total	3,293	3,216	3,334	3,214[r]	3,292
Kazakhstan, byproduct:[e]					
Metallurgy	300	300	300	300	300
Natural gas and petroleum	1,700	1,661[4]	1,733[4]	1,700	1,700
Total	2,000	1,961	2,033	2,000	2,000
Korea, Republic of, byproduct:[e]					
Metallurgy	--[r]	--[r]	--[r]	--[r]	--
Petroleum	660[r]	670[r]	600[r]	660[r]	660
Total	660[r]	670[r]	600[r]	660[r]	660
Kuwait, byproduct, natural gas and petroleum[e]	830[r]	830	800[r]	830	830
Mexico, byproduct:					
Metallurgy[e]	650	550	700	700	700
Natural gas and petroleum	1,074	1,026	1,041	1,114[r]	1,110
Total	1,724	1,576	1,741	1,814[r]	1,810
Netherlands, byproduct:[e]					
Metallurgy	130	130	130	130	130
Petroleum	400	400	400	400	400
Total	530	530	530	530	530
Poland:[e, 5]					
Native	800	834	762	263[r, 4]	517[4]
Byproduct:					
Natural gas	20	23	21	25[r]	25
Petroleum	182	188	201[r]	190[r]	190
Total	1,000	1,050	984[r]	478[r]	732
Qatar, byproduct, natural gas	360[e]	360[e]	527	658	1,124
Russia:[e, 6]					
Native	50	50	50	50	50
Pyrites	200	200	200	200	200
Byproduct:					
Metallurgy	700	800	820	820	820
Natural gas	6,000	6,000	6,100	6,000	6,000
Total	6,950	7,050	7,170	7,070	7,070
Saudi Arabia, byproduct, all sources	2,907	3,089	3,163	3,200[e]	3,300[e]
South Africa:					
Pyrites, S content, from gold mines	68	71	61	60	30
Byproduct:					
Metallurgy, copper, platinum, zinc plants	231	236	187	175[r, e]	160[e]
Petroleum	343	335	323	300[r, e]	275[e]
Total	643	642	571	535[r, e]	465[e]

See footnotes at end of table.

TABLE 11—Continued

SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE[1, 2]

(Thousand metric tons)

Country and source[3]	2006	2007	2008	2009	2010
Spain, byproduct:[e]					
Coal, lignite, gasification	1	1	1	1	1
Metallurgy	500	500	500	500	500
Petroleum	117 [4]	136 [4]	136 [4]	136 [4]	136
Total	618	637	637	637	637
United Arab Emirates, byproduct, natural gas and petroleum[e]	1,950	1,950	2,175 [4]	2,000	1,763 [4]
United States, byproduct:					
Metallurgy	674	817	753	749	791
Natural gas	1,430	1,280	1,300	1,220	1,170
Petroleum	6,960	7,000	7,240	6,970	7,120
Total	9,060	9,100	9,300	8,940	9,080
Uzbekistan, byproduct:[e]					
Metallurgy	170	170	170	170	170
Natural gas and petroleum	350	350	350	350	350
Total	520	520	520	520	520
Venezuela, byproduct, natural gas and petroleum[e]	800	800	800	800	800
Other[e]	3,820 [r]	3,880 [r]	3,890 [r]	3,690 [r]	4,020
Of which:					
Native	218 [r]	218 [r]	228 [r]	209	215
Pyrites	167 [r]	190 [r]	205 [r]	106	64
Unspecified	1,150	1,150 [r]	1,160 [r]	1,190 [r]	1,170
Byproduct:					
Metallurgy	1,020 [r]	1,030 [r]	1,020 [r]	1,000 [r]	1,000
Natural gas[7]	-- [r]	-- [r]	-- [r]	-- [r]	--
Other—Continued:[e]					
Of which:					
Byproduct—Continued:					
Natural gas and petroleum, undifferentiated[8]	482 [r]	472	428	423 [r]	461
Petroleum	780 [r]	820 [r]	845 [r]	759 [r]	1,110
Grand total	67,000 [r]	67,600 [r]	68,100 [r]	66,600 [r]	68,100
Of which:					
Frasch	21	22	22	22	22
Native	2,020 [r]	2,060 [r]	2,000 [r]	1,520	1,880
Pyrites	4,530 [r]	4,940 [r]	5,050 [r]	5,020 [r]	4,950
Unspecified	4,810 [r]	4,940 [r]	5,020 [r]	5,090 [r]	5,170
Byproduct:					
Coal, lignite, gasification[e]	1	1	1	1	1
Metallurgy	16,200 [r]	16,500 [r]	16,700 [r]	16,800 [r]	17,400
Natural gas[7]	7,810	7,670	7,950	7,900	8,320
Natural gas and petroleum, undifferentiated[8]	19,300 [r]	19,000 [r]	18,700 [r]	18,100 [r]	17,700
Petroleum	12,300 [r]	12,400 [r]	12,700 [r]	12,200 [r]	12,700

[e]Estimated. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through September 28, 2011.

TABLE 11—Continued
SULFUR: WORLD PRODUCTION IN ALL FORMS, BY COUNTRY AND SOURCE [1, 2]

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[3] The term "source" reflects the means of collecting sulfur and the type of raw material. Sources listed include the following: Frasch recovery; native comprising all production of elemental sulfur by traditional mining methods (thereby excluding Frasch); pyrites (whether or not the sulfur is recovered in the elemental form or as acid); byproduct recovery, either as elemental sulfur or as sulfur compounds from coal gasification, metallurgical operations including associated coal processing, crude oil and natural gas extraction, petroleum refining, oil sand cleaning, and processing of spent oxide from stack-gas scrubbers; and recovery from processing mined gypsum. Recovery of sulfur in the form of sulfuric acid from artificial gypsum produced as a byproduct of phosphatic fertilizer production is excluded, because to include it would result in double counting. Production of Frasch sulfur, other native sulfur, pyrite-derived sulfur, mined gypsum derived sulfur, byproduct sulfur from extraction of crude oil and natural gas, and recovery from oil sands are all credited to the country of origin of the extracted raw materials. In contrast, byproduct recovery from metallurgical operations, petroleum refineries, and spent oxides are credited to the nation where the recovery takes place, which may not be the original source country of the crude product from which the sulfur is extracted.

[4] Reported figure.

[5] Government of Poland sources report total Frasch and native mined elemental sulfur output annually, undifferentiated.

[6] Sulfur is thought to be produced from Frasch and as a petroleum byproduct; however, information is inadequate to formulate estimates.

[7] Excludes "Ecuador, natural gas."

[8] Includes "Ecuador, natural gas."

TALC AND PYROPHYLLITE

By Robert L. Virta

Domestic survey data and tables were prepared by Robin C. Kaiser, statistical assistant, and the world production table was prepared by Glenn J. Wallace, international data coordinator.

In 2010, talc production increased to 604,000 metric tons (t) valued at $19.1 million from 511,000 t valued at $14.6 million in 2009. Sales of talc increased to 567,000 t valued at $84.9 million from 512,000 t valued at $57.2 million in 2009. U.S. apparent consumption of talc increased to 622,000 t in 2010 from 457,000 t in 2009. Exports of talc increased to 224,000 t in 2010 from 188,000 t in 2009, and imports increased to 242,000 t in 2010 from 134,000 t in 2009. U.S. production and sales of pyrophyllite increased in 2010 (data are withheld to avoid disclosing proprietary information). World production of talc and pyrophyllite was unchanged at 7.2 million metric tons (Mt) in 2010 from that of 2009.

Legislation and Government Programs

In 2010, the U.S. Department of Defense authorized the disposal of 865 t of block and lump talc and 621 t of ground talc, the entire uncommitted inventory of the National Defense Stockpile (NDS). There were no sales from the NDS in 2010.

Production

Talc.—Domestic production data were obtained through a voluntary survey of U.S. mining companies conducted by the U.S. Geological Survey (USGS). Survey forms were sent to six companies that mined talc, and responses were received from four companies. Responses accounted for essentially all of the production data presented in table 1. Data for the nonrespondents were estimated from preliminary reported data based on 9 months of production in 2010, reported prior-year data adjusted according to employment and consuming industry trends and Mine Safety and Health Administration employment data.

In 2010, three companies operating six mines in three States mined talc. All were open pit mining operations. The producers were, in decreasing order of production, Luzenac Group (a division of Rio Tinto plc) in Montana and Vermont, Specialty Minerals Inc. (a subsidiary of Minerals Technologies Inc.) in Montana, and American Talc Co. in Texas. Alberene Soapstone Co. in Virginia and CAL-TALC, Inc. in California worked from stockpiles in 2010. The three leading domestic producers collectively accounted for all of the U.S. tonnage mined.

U.S. mine production increased to 604,000 t valued at $19.1 million compared with 511,000 t valued at $14.6 million in 2009 (table 1). Production rebounded from that of 2009 because of increased manufacturing activity associated with the economic recovery in the United States and many other countries. Production increased in Montana and Vermont and remained unchanged in Texas. Montana led all States in the tonnage of talc produced, followed by Texas and Vermont.

Pyrophyllite.—Domestic production data of pyrophyllite (a hydrous aluminum silicate with a structure similar to talc) were acquired through a voluntary USGS survey of the two U.S. companies. One company responded to the survey. Data for the nonrespondent were estimated from preliminary reported data based on 9 months of production in 2010, reported prior-year data adjusted according to employment and consuming industry trends, and Mine Safety and Health Administration employment data.

Standard Mineral Co. operated two mines in North Carolina, and Standard Industrial Minerals, Inc. operated one mine in California. U.S. production increased slightly in 2010 in response to increased manufacturing activity in the United States. Domestic data were withheld to avoid revealing company proprietary data.

Consumption

Domestic consumption data for talc and pyrophyllite were developed by the USGS from a voluntary survey of U.S. mills. Survey forms were sent to 7 companies operating 10 mills in 6 States for talc and 2 companies operating 2 mills in 2 States for pyrophyllite. Responses from four companies accounted for more than 99% of the talc data presented in table 2. The remaining data were estimated from preliminary data based on 9 months of production in 2010, reported prior-year data adjusted according to employment and consuming industry trends, and Mine Safety and Health Administration employment data.

Talc.—Sales and use were 567,000 t of talc valued at $84.9 million in 2010, an increase from 512,000 t valued at $57.2 million in 2009 (table 1). U.S. producers reported that talc sold domestically and not exported increased to 454,000 t in 2010 from 421,000 t in 2009. Ceramics (mainly ceramic tiles) was the leading market, followed by paper, paint, roofing, plastics, cosmetics, and rubber, in decreasing order of consumption (table 2). Sales to the domestic ceramics, paint, paper, and roofing industries each increased more than 8% in 2010 compared with those of 2009. Domestic sales for cosmetics and plastics applications increased slightly and sales to rubber markets decreased in 2010. The largest increase was, by tonnage, in sales for paper applications.

Specialty Minerals reported that revenue from talc sales increased to $44 million in 2010 from $32.3 million in 2009, a result of a 9% increase in tonnage sold and increased prices for talc products. Sales to residential and commercial construction and automotive markets by the company improved in 2010 (Minerals Technologies Inc., 2011a, p. 22).

Sales of talc to manufacturers of ceramics (mainly tile), paint, and roofing were tied to commercial and home construction and renovation. Construction starts for new privately owned housing increased to 588,000 units in 2010 from 554,000 units in 2009, but the value of all construction (residential and commercial) decreased to $815 billion in 2010 from $908 billion in 2009 (U.S. Census Bureau, 2011a, c).

Shipments of architectural paint (a major paint market for talc) increased to 2.49 billion liters (659 million gallons) in 2010 from 2.34 billion liters (617 million gallons) in 2009 (U.S. Census Bureau, 2011d). The U.S. International Trade Commission (undated) reported that imports of ceramic tile under Harmonized Tariff Schedule of the United States (HTS) codes 6907.10.00, 6908.10.10, 6908.10.20, and 6908.10.50 increased in quantity to 7.10 million square meters valued at $68.4 million in 2010 from 6.95 million square meters valued at $68.6 million in 2009. Ceramic tile is a major market for talc, and U.S. producers sell their talc to domestic tile manufacturers, whose tile competes with imported ceramic tile.

Most of the 242,000 t of imported talc listed in table 4 was not included in the domestic end-use data in table 2. An estimated end-use breakdown of sales of imports in 2010 is plastics, 140,000 t; cosmetics, 30,000 t; paint, 25,000 t; ceramics and refractory products, 12,000 t; paper, 10,000 t; rubber, 8,000 t; and other (unspecified), 17,000 t. Combining domestic sales by U.S. producers (table 2) with sales of imported talc, markets in the United States were, in decreasing order of consumption, plastics, ceramics, paint, paper, cosmetics, roofing, and rubber.

Pyrophyllite.—In 2010, domestic consumption of pyrophyllite increased from that of 2009; data are withheld to avoid disclosing company proprietary data. Pyrophyllite was used in refractory products, paint, ceramics, and unspecified applications, in decreasing order of consumption. Refractory uses accounted for more than 50% of domestic pyrophyllite sales.

Prices

In 2010, the unit value of crude talc was estimated to be $32 per metric ton compared with $29 per ton in 2009. Nearly all talc sold in the United States was sold only after crushing and grinding. Following sorting to remove waste, primary crushing, and screening, the unit value of the unmilled talc would likely range from $50 to $60 per ton. The average reported unit value of processed talc was $150 per ton in 2010, a large increase from the unit value of $112 per ton in 2009. The higher unit value in 2010 resulted largely from increased sales to higher value talc markets, such as paint and paper, as well as price increases that reflected increased operating costs. The unit values of crude and processed pyrophyllite were essentially unchanged in 2010.

The average free alongside ship unit value of all exports increased to $211 per ton in 2010 from $200 per ton in 2009 (table 3). The unit value for milled talc (HTS code 2526.20.00.00) exports increased to $210 per ton in 2010 from $199 per ton in 2009. The average free alongside ship unit value for exports of unmilled talc (HTS code 2526.10.00.00) increased slightly to $465 per ton in 2010 from $460 per ton in 2009. The unit value of unmilled talc was greater than milled talc because there were large numbers of high-value, low-tonnage exports of unmilled talc; milled talc had more large-tonnage, low-value exports.

The average Customs unit value for all talc imports was $278 per ton in 2010 compared with $357 per ton in 2009. The average unit value for imports of unground talc (HTS code 2526.10.00.00) was $206 per ton in 2010, a decrease from $287 per ton in 2009. Lower prices for unground talc from China were largely responsible for the decline in unit value. The average customs value for ground talc (HTS code 2526.20.00.00) was $235 per ton in 2010, a decrease from $252 per ton in 2009. Lower prices for ground talc from Canada and China were largely responsible for the decline in unit value. The average customs value for cut or sawed talc (HTS code 6815.99.20.00) was $975 per ton, a decrease from $1,080 per ton in 2009 (table 4).

Foreign Trade

This section summarizes significant trade statistics on talc. Detailed statistics, by country and U.S. port districts, are available from the U.S. International Trade Commission on its Interactive Tariff and Trade Dataweb Website (U.S. International Trade Commission, undated). Trade in talc increased in 2010 compared with that in 2009 as the economies of many nations began to recover from the 2008–09 economic recession. U.S. talc exports increased in tonnage to 224,000 t valued at $47.2 million in 2010 from 188,000 t valued at $37.6 million in 2009. By tonnage, Mexico was the leading destination for talc from the United States with 78,000 t, followed by Canada with 54,000 t (table 3). These two countries accounted for 59% of U.S. exports. The remainder was exported to 60 other countries. About 94% of talc exports were milled.

U.S. talc imports increased to 242,000 t valued at $67.1 million in 2010 from 134,000 t valued at $47.9 million in 2009. Canada and China accounted for most of the increase in imports. By tonnage, China was the leading source for imported talc, with 44% of the tonnage, followed by Canada with 38% of the tonnage (table 4). The remainder was imported from 32 other countries. Imports from Japan were likely pyrophyllite rather than talc.

World Review

World production of talc and pyrophyllite was estimated to be 7.2 Mt in 2010, unchanged from that of 2009. China was the world's leading producer of talc, followed by, in decreasing order by quantity, the United States, India, Finland, and France (crude). The Republic of Korea was the leading producer of pyrophyllite, followed by Japan and Brazil. Brazil, China, Finland, France, India, Japan, the Republic of Korea, and the United States together produced 78% of the world's talc and pyrophyllite (table 5).

Rio Tinto plc, the parent company for Rio Tinto Minerals, began accepting bids for its talc division in 2010 and by early 2011, Imerys, a French investment company made a binding offer of $340 million for the talc division. Rio Tinto reported that talc production in 2010 increased to 1 Mt in its global operations compared with 888,000 t in 2009 as sales increased in paper, paint, and polmer markets (Rio Tinto plc, 2011b, p. 50, 53, and 82).

Australia.—Rio Tinto Minerals, a division of Rio Tinto plc, began operating a new $11 million talc beneficiation plant at its Three Spring mine. The new plant can crush, screen, and wash up to 200 metric tons per hour of primary ore. Overall capacity was 150,000 tons per year of high grade ore. The plant was 30% more energy efficient than the old plant (Rio Tinto Minerals, 2010).

Canada.—Sherritt International Corp., announced that it would close its Canada Talc mine and plant in Madoc and Marmora, Ontario. The company indicated that the cost of mining talc underground was no longer economically viable at those operations. Its mine had been in operation for about 130 ears (Sherman, 2010; Sherritt International Corp., 2011, p. 48).

Spain.—Rio Tinto Minerals announced plans to close its Respina talc mine in Leon in 2011. The mine, which operated or 35 years, had exhausted its talc reserves. Rio Tinto also operated a talc mine near Malaga (Watts, 2010).

Outlook

In 2010, the global talc industry showed signs of recovery rom the 2008–09 worldwide economic recession. U.S. ndustrial production increased 5% through April 2011 compared with the same time period in 2010 (Federal Reserve Board, The, 2011). The value of manufacturers' shipments ncreased 4.8% for automobiles, 23.9% for light trucks and utility vehicles, 3.8% for paper products, and 4.9% for plastics and rubber products (U.S. Census Bureau, 2011b). This suggests that talc used in catalytic converter bodies (ceramics), automotive and truck body and underhood components plastics), printing papers (pitch control), and rubber (fillers and extenders in tires and other rubber components) may increase for the next 1 to 2 years. Paint shipments increased in 2010 but slowed in early 2011 (U.S. Census Bureau, 2011b, d). The slow commercial and residential construction markets in the United States are likely to affect sales of talc into such markets as adhesives, caulks, ceramics (particularly ceramic tile), joint compounds, architectural paint, and roofing for the next 1 to 2 years.

Rio Tinto and Minerals Technologies reported increased production of talc (5% and 12%, respectively) in the first quarter of 2011, compared with that of the first quarter of 2010 (Minerals Technologies Inc., 2011b; Rio Tinto plc, 2011a). These increases, by the two leading U.S. producers of talc, suggested that U.S. talc production and sales may rebound 8% to 12% overall in 2011. The growth in world talc production is likely to be similar to that of the United States. U.S. pyrophyllite production and sales increased slightly in 2010 as the U.S. economy began to recovery from the 2008–09 recession. Sales to major industries that use pyrophyllite to produce ceramic, paint, and refractory products are likely to increase 3% or 4% per year in the next few years.

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TABLE 1
SALIENT TALC AND PYROPHYLLITE STATISTICS[1]

(Thousand metric tons and thousand dollars)

	2006	2007	2008	2009	2010
United States:					
Mine production, crude:					
Quantity:					
Talc	895	769	706	511	604
Pyrophyllite	W	W	W	W	W
Value:					
Talc	27,400	24,400	21,800	14,600	19,100
Pyrophyllite	W	W	W	W	W
Sold by producers, crude and processed:					
Quantity:					
Talc	900	720	667	512	567
Pyrophyllite	W	W	W	W	W
Value:					
Talc	81,300	82,000	83,300	57,200	84,900
Pyrophyllite	W	W	W	W	W
Exports, talc:[2]					
Quantity	253	271	244	188	224
Value	46,800	50,600	46,000	37,600	47,200
Imports for consumption, talc:					
Quantity	314	221	193	134 [r]	242
Value	66,700	64,100	56,400	47,900	67,100
Apparent consumption[3]	956	719	655	457	622
World, production	7,770	7,730 [r]	7,590 [r]	7,230 [r]	7,210 [e]

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes powder—talcum (in package), face, and compact.

[3] Production plus imports minus exports plus adjustments in Government and industry stocks. Does not include pyrophyllite.

TABLE 2
END USES FOR TALC
PRODUCED IN THE UNITED STATES

(Thousand metric tons)

	2009	2010
Ceramics[1]	95	111
Cosmetics	16	16
Paint	81	88
Paper	81	101
Plastics	39	40
Roofing	31	41
Rubber	14	11
Other[2]	65	47
Total	421	454

[1] Includes tile.

[2] Includes art sculpture, construction caulks, insecticides, joint compound, and other uses not specified.

TABLE 3
U.S. EXPORTS OF TALC[1, 2]

(Thousand metric tons and thousand dollars)

Country	2009		2010	
	Quantity	Value[3]	Quantity	Value[3]
Belgium	--	--	3	504
Canada[4]	54	10,400	54	10,700
Germany	--	--	(5)	72
Japan	5	743	5	1,040
Mexico	67	6,850	78	7,870
Singapore	3	1,170	11	3,810
Other[6]	59	18,400	73	23,200
Total	188	37,600	224	47,200

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes powders—talcum (in package), face, and compact.

[3] Free alongside ship.

[4] Probably includes shipments in transit through Canadian ports.

[5] Less than ½ unit.

[6] Includes 53 countries in 2009 and 56 countries in 2010.

Source: U.S. Census Bureau, data adjusted by the U.S. Geological Survey.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF TALC, BY COUNTRY[1]

	Not crushed or powdered		Crushed or powdered		Cut and sawed		Total unmanufactured	
Country	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)	Quantity (metric tons)	Value[2] (thousands)
2009:								
Brazil	3	$5	172	$34	1,160	$936	1,340	$975
Canada	13	24	35,800	13,600	12,800	14,700	48,600	28,400
China	45,600	12,800	5,400	826	331	194	51,300	13,900 r
France	--	--	568	159	--	--	568	159
Japan	--	--	5,700	1,350	48	25	5,750	1,380
Other[3]	10	221	26,000 r	2,600	739	376	26,700 r	3,200
Total	45,600	13,100	73,600 r	18,600	15,100	16,300	134,000 r	47,900
2010:								
Brazil	31	41	147	35	973	1,210	1,150	1,280
Canada	14	19	76,600	19,300	15,100	13,400	91,700	32,700
China	77,900	15,500	26,400	3,630	833	935	105,000	20,100
France	--	--	1,910	726	--	--	1,910	726
Japan	--	--	3,000	1,460	40	106	3,040	1,570
Other[3]	6,010	1,670	32,200	7,780	425	1,290	38,600	10,700
Total	84,000	17,300	140,000	32,900	17,400	16,900	242,000	67,100

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] U.S. Customs declared value.

[3] Includes 23 countries in 2009 and 29 countries in 2010.

Source: U.S. Census Bureau.

TABLE 5
TALC AND PYROPHYLLITE: WORLD PRODUCTION, BY COUNTRY AND PRODUCT[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Argentina, talc and related materials	23,113 [r]	24,836 [r]	22,218 [r]	22,894 [r]	23,000
Australia:[e, 4]					
Pyrophyllite	1,200	1,200	1,200	1,200	1,200
Talc	130,000	120,000	120,000	120,000	120,000
Austria, soapstone and talc, crude	159,447	153,409	154,577	111,388 [r]	150,000
Bhutan, talc	45,000 [e]	62,015	56,077	56,000 [r]	60,000
Brazil, talc and pyrophyllite	389,471	401,204	401,210	401,300	410,000
Canada, pyrophyllite, soapstone, talc	72,000	79,000	70,000 [e]	44,000	96,000
Chile, talc	1,961	2,104	2,108	1,202 [r]	1,500
China, unspecified[e]	2,400,000	2,000,000	2,200,000	2,300,000	2,000,000
Egypt, pyrophyllite, soapstone, steatite, talc	40,000 [e]	67,000 [r]	69,000 [r]	72,000 [r]	75,000
Finland, talc[e]	550,000	550,000	550,000	500,000	500,000
France, talc, crude[e]	420,000	420,000	420,000	420,000	420,000
Guatemala, talc	526	1,291	1,030	6,355	5,000
Hungary, talc[e]	500	500	500	500	500
India:[e]					
Pyrophyllite	86,000	87,000	87,000	88,000	87,000
Steatite	560,000	555,000	560,000	550,000	550,000
Iran, talc[e, 5]	70,000	90,889 [6]	90,000	90,000	90,000
Italy, steatite and talc[e]	146,942 [6]	140,000	140,000	140,000	140,000
Japan:[e]					
Pyrophyllite	350,000	345,000	350,000	340,000	340,000
Talc	25,500	26,000	26,000	25,000	24,000
Korea, North, unspecified[e]	50,000	50,000	50,000	50,000	50,000
Korea, Republic of:					
Pyrophyllite	677,465	798,054	892,625	617,411 [r]	700,000
Talc	64,118	9,557	6,438	5,996 [r]	6,000
Macedonia, talc	1,025	1,775	977	-- [r]	--
Mexico, talc	9,834	9,800 [e]	17,577 [r]	33,421 [r]	33,000
Morocco[e]	2,000	2,000	2,000	2,000	2,000
Nepal, talc[7]	6,648	9,043	9,040 [e]	9,000	9,000
Norway, soapstone, steatite, talc[e]	28,000	28,000	28,000	28,000	26,000
Pakistan, pyrophyllite	24,529	32,675 [r]	33,000 [r]	35,000 [r]	34,000
Paraguay, pyrophyllite, soapstone, talc[e]	200	200	200	200	200
Peru:					
Pyrophyllite	14,500	13,925	14,733	14,750 [4]	14,800
Talc	9,550	9,171	17,984	13,296 [4]	13,300 [p]
Portugal, talc	5,517	12,367	8,447	8,500	8,500
Romania, talc[e]	2,967 [6]	1,513 [6]	1,700 [r]	500 [r]	1,000
Russia, talc[e]	160,000	170,000	160,000	160,000	160,000
South Africa:					
Pyrophyllite	74,886	123,573	80,704	114,889 [r]	122,511 [6]
Talc	10,966	14,281	5,145	4,718 [r]	3,150 [6]
Spain, steatite and talc[e]	100,000	100,000	100,000	100,000	100,000
Sweden, soapstone and talc[e]	14,000 [6]	14,000	14,000	14,000	14,000
Thailand:					
Pyrophyllite	131,843	415,420	106,600	200,000 [r]	200,000
Talc	4,374	3,508	3,264	3,000 [e]	3,000
Turkey, talc and pyrophyllite	4,969	12,722	3,364 [r]	6,887 [r]	8,000

See footnotes at end of table.

TABLE 5—Continued

TALC AND PYROPHYLLITE: WORLD PRODUCTION, BY COUNTRY AND PRODUCT[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
United Kingdom, pyrophyllite, soapstone, talc[e]	6,000 [4]	6,000	6,000	6,000	6,000
United States:					
Pyrophyllite	W	W	W	W	W
Talc	895,000	769,000	706,000	511,000	604,000 [6]
Uruguay, pyrophyllite, soapstone, talc[e]	1,150	1,150	1,150	1,150	1,150
Zimbabwe, talc[e]	140	200	200	200	200
Grand total	7,770,000	7,730,000 [r]	7,590,000 [r]	7,230,000 [r]	7,210,000
Of which:					
Pyrophyllite	1,360,000 [r]	1,820,000	1,570,000	1,410,000 [r]	1,500,000
Steatite	560,000	555,000	560,000	550,000	550,000
Talc	2,410,000 [r]	2,280,000 [r]	2,200,000 [r]	1,970,000 [r]	2,060,000
Unspecified	3,440,000 [r]	3,080,000 [r]	3,260,000 [r]	3,300,000 [r]	3,100,000

[e]Estimated. [p]Preliminary. [r]Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through April 29, 2011.

[3] In addition to the countries listed, Nigeria may produce talc, but information is inadequate to estimate output.

[4] Data based on fiscal year ending June 30 of year stated.

[5] Data based on fiscal year beginning March 21 of year stated.

[6] Reported figure.

[7] Data based on fiscal year beginning mid-July of year stated.

THORIUM

By E. Lee Bray

Domestic survey data and tables were prepared by Martha L. Jackson, statistical assistant, and the world production table as prepared by Lisa D. Miller, international data coordinator.

Thorium consumption worldwide is relatively small ompared with that of most other mineral commodities. There as no domestic production of thorium reported in 2010. All orium alloys, compounds, and metal used by the domestic dustry were derived from company stocks, imports, or aterial previously acquired from the U.S. Government tockpile. Domestic imports for consumption of refined horium products increased by 35% in 2010, according to data ollected by the U.S. Census Bureau (tables 1, 2). The value f thorium compounds used by the domestic industry in 2010 as $208,000, a decrease of 24% from $275,000 in 2009. nly minor amounts, less than 10 metric tons (t) of thorium, re typically used annually. However, large fluctuations in onsumption are caused by intermittent use, especially for atalytic applications that do not require annual replenishment. 2010, India (87%) and France (13%) were the leading sources f thorium compound imports.

Thorium has been found to some extent in every continent f the world, but is concentrated in a few geologic deposit pes. There are three principal sources of thorium that are of ommercial interest—monazite in heavy-mineral sand placer nd vein deposits, thorite ores in vein deposits, and thorium ecovered as a byproduct of uranium mining. Thorium and s compounds were produced primarily from the mineral onazite, which was recovered as a byproduct of processing eavy-mineral sands for zircon and the titanium minerals, menite and rutile, or the tin mineral cassiterite. Monazite was ecovered primarily for its rare-earth content, and only a small action of the byproduct thorium produced was consumed. onazite-producing countries were, in decreasing order of roduction, India, Brazil, and Malaysia (table 3).

Problems associated with thorium's natural radioactivity epresented a significant cost to those companies involved in s mining, processing, manufacture, transport, and use. The osts to comply with environmental regulations and potential gal liabilities and the high costs to purchase storage and waste isposal space were the principal deterrents to its commercial se.

Limited demand for thorium, compared with demand for rare arths produced from thorium-containing minerals, continued create a worldwide oversupply of thorium compounds and esidues. Most major rare-earth processors have switched feed aterials to thorium-free intermediate compounds, such as are-earth chlorides, hydroxides, or nitrates. Excess thorium ot designated for commercial use was either disposed of as low-level radioactive waste or stored for potential use as a uclear fuel or in other applications. Principal nonenergy uses ave shifted from refractory applications to chemical catalysts, ghting, welding electrodes, and heat resistant ceramics, in escending order of use.

Production

Domestic mine production data for thorium-bearing minerals were developed by the U.S. Geological Survey from a voluntary canvass of U.S. thorium operations. The one mine to which a canvass form was sent responded. Thorium was not produced in the United States in 2010, and the mine that had previously produced thorium-bearing monazite at Green Cove Springs, FL, (Iluka Resources Inc., a wholly owned subsidiary of Iluka Resources Ltd.) ceased production of zircon from tailings during 2009. The monazite production capacity has been on care-and-maintenance status for several years. Monazite was last produced in the United States in 1994.

Consumption

Statistics on domestic thorium consumption were developed by evaluating import and export data, and surveying various processors and manufacturers. Domestic thorium producers and processors that were surveyed reported no consumption of thorium oxide equivalent in 2010 and were temporarily shut down owing to the lack of thorium demand. Additional information on domestic consumption was not available. Essentially all thorium alloys and compounds used by the domestic industry were derived from imports, company stocks, or materials previously sold from the National Defense Stockpile. Domestic companies processed or fabricated various forms of thorium for nonenergy uses, such as ceramics, chemical catalysts, lighting, and welding electrodes. Lightbridge Corp. (McLean, VA) continued work on the design of a light water reactor using thorium (Lightbridge Corp., 2010).

Prices

Thorium oxide prices in 2010, as quoted by Rhodia Inc. (Cranbury, NJ) [a subsidiary of Rhodia S.A. (La Rochelle, Poitou-Charentes, France)] were estimated to be the same as those of the previous year (table 1). At yearend, the estimated price for thorium oxide delivered, duty paid, was $300 per kilogram for 99.9% purity, the same as that at yearend 2009. In 2007, the 99.99%-pure thorium oxide product was discontinued. Thorium nitrate prices from Rhodia were estimated to be unchanged at $27 per kilogram for mantle-grade material. Thorium nitrate was used in the manufacture of mantles for incandescent "camping" lanterns, including natural gas lamps and oil lamps. Thorium mantles provide an intense white light that is adjusted toward the yellow region by a small addition of cerium. Thoriated mantles were not produced domestically owing to the development of a suitable thorium-free substitute.

Foreign Trade

Exports of thorium compounds from the United States were 1,500 kilograms (kg) valued at $605,000, a decrease from 4,730 kg in 2009 (table 2). Principal destinations were, in order of quantity, Singapore, Canada, the United Kingdom, and Saudi Arabia.

Imports of thorium compounds in 2010 totaled 3,030 kg valued at $208,000, an increase from 2,250 kg valued at $275,000 in 2009. India and France were, in order of quantity, the leading suppliers of thorium imports in 2010 (table 2). Rhodia's rare-earth separation plant in La Rochelle remained the principal source of thorium compounds imported into the United States. Most of the thorium was supplied from older stocks that were produced when the plant was processing monazite. In 2010, the La Rochelle plant processed intermediate rare-earth concentrates that had the thorium removed. No thorium ores or concentrates were imported in 2010; imports of thorium ores and concentrates including monazite were 26,000 kg in 2009.

World Review

Thorium demand worldwide remained depressed because of concerns about its naturally occurring radioactivity. Industrial consumers expressed concerns about the potential liabilities, the cost of environmental monitoring to comply with regulations, and the cost of disposal at approved waste burial sites. Interest in thorium increased worldwide, however, as various countries exhibited an interest in thorium-fueled nuclear power as an alternative to uranium. In 2010, exploration for rare-earth elements associated with thorium continued in Canada, India, and the United States.

France.—Areva Inc. (Paris, France) announced construction of a facility in Bessines to extract lead 212 for use in experimental cancer treatments. Lead 212 is a daughter product of thorium 232, and Areva planned to extract the lead from thorium using proprietary technology. The facility would be completed in 2013 (Areva Inc., 2010).

India.—The Indian Department of Atomic Energy designed a 300-megawatt (MW) advanced heavy water reactor fueled by thorium. The reactor would be built at Kalpakkam, where an experimental thorium reactor was already located. The reactor was scheduled for completion by 2019 (Outlook India, 2010; Sabha, 2010).

Indian Rare Earths Ltd. planned to construct a monazite processing plant at its Orissa Sands Complex in the Ganjam district. The plant would have a capacity of 10,000 metric tons per year and be operational in 2013 (Hindu, The, 2010).

Japan.—International Thorium Energy Molten-Salt Technology Inc. announced plans to develop a thorium molten salt reactor. Thorium fluoride fuel would be dissolved in molten beryllium and lithium fluoride salts. The reactor would operate at normal pressure, a design that is perceived to be safer than the solid-fuel reactors that operate in high-pressure containers. A 10 MW pilot plant would be built, and then, a 200 MW powerplant is proposed if the pilot plant is successful. A schedule was not available (International Thorium Energy Organization, 2010).

Outlook

Thorium use in the United States has decreased substantially since the early 1990s. Domestic consumption is expected to remain at recent low levels unless thorium's use as a nonproliferative nuclear fuel becomes widely commercialized or a low-cost technology is developed to dispose of thorium residues created as a byproduct during mineral processing, specifically monazite. In the long term, high disposal costs, increasingly stringent regulations, and public concerns related to thorium's natural radioactivity are expected to continue to discourage its use in global nonenergy applications. Interest in thorium-powered nuclear reactors was expected to increase, especially after the accidents at nuclear reactors in Japan, which were damaged by tsunamis triggered by an earthquake on March 11, 2011.

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TABLE 1
SALIENT U.S. REFINED THORIUM STATISTICS[1]

(Kilograms and dollars per kilogram)

	2006	2007	2008	2009	2010
Exports, gross weight:					
Thorium ore, including monazite	--	-- [2]	-- [2]	18,000	(3)
Compounds	1,090	1,630	12,600	4,730	1,500
Imports for consumption, gross weight:					
Thorium ore, including monazite	10,000	--	--	26,000	--
Compounds	48,600	6,370	692	2,250	3,030
Prices, yearend:					
Nitrate, gross weight[4, 5]	27.00	27.00	27.00	27.00	27.00 [e]
Oxide, 99.9% purity[5]	175.00	200.00	300.00	300.00	300.00 [e]

[e] Estimated. -- Zero.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Data estimated by the U.S. Geological Survey.

[3] Less than ½ unit.

[4] Source: Rhodia Canada Inc., free on board port of entry, duty paid, thorium oxide basis.

[5] Source: Rhodia Inc.

TABLE 2
U.S. FOREIGN TRADE IN THORIUM AND THORIUM-BEARING MATERIALS[1]

	2009		2010		
	Quantity (kilograms)	Value	Quantity (kilograms)	Value	Principal destinations/sources and quantities, 2010
Exports:					
Thorium ore, monazite concentrate	18,000	$269,000 [2]	(3)	$15,200	Algeria.
Compounds	4,730	379,000	1,500	605,000	Singapore 600; Canada 250; United Kingdom 250; Saudi Arabia 210.
Imports for consumption:					
Thorium ore, monazite concentrate	26,000	19,500	--	--	XX
Compounds	2,250	275,000	3,030	208,000	India 2,620; France 400.

XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Data estimated by the U.S. Geological Survey.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3
MONAZITE CONCENTRATE: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, gross weight)

Country[3]	2006	2007	2008	2009	2010
Brazil	958 [4]	1,173 [4]	1,200	1,200	1,200
India	5,000	5,000	5,000	5,000	5,000
Malaysia	894 [4]	682 [4]	233 [r]	25 [r]	30
Total	6,850	6,860	6,430 [r]	6,230 [r]	6,230

[r] Revised.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 9, 2011.

[3] In addition to the countries listed, China, Indonesia, Nigeria, North Korea, the Republic of Korea, and countries of the Commonwealth of Independent States may produce monazite, available information is inadequate for formulation of reliable estimates of ouput levels.

[4] Reported figure.

TIN

By James F. Carlin, Jr.

Domestic survey data and tables were prepared by Linda M. White, statistical assistant, and the world production tables were prepared by Lisa D. Miller, international data coordinator.

Tin has not been mined in the United States since 1993; consequently, the country was reliant on imports and recycling for its tin needs. In 2010, 25 firms consumed 91% of the primary tin used domestically. The major uses were as follows: metal containers, 19%; solders, 18%; transportation, 16%; construction, 10%; and other, 37%. The estimated value of primary tin metal consumed domestically was $689 million. Industry stocks declined by 9% compared with those at yearend 2009.

In 2010, approximately 13,600 metric tons (t) of tin scrap, most of it from old scrap was produced (table 5). About 16% of the tin consumed in the United States was recycled metal.

World tin mine output declined slightly compared with that in 2009, and world primary tin smelter production increased by 3% compared with that in 2009 (tables 1, 9, 10). Of the 18 countries in which tin was mined, the top 5 accounted for 90% of the total world tin production of 277,000 t. China was the leading producer (43% of world output), followed by Indonesia (20%), and Peru (12%).

Industry analysts considered the world tin market in 2010 to have a moderate deficit of supply relative to consumption. The composite tin price increased by 48% from that of 2009. World tin reserves were estimated to be 5.2 million metric tons (Mt), about 15 times the estimated world primary tin consumption of 350,000 t. Most tin reserves were in Asia and South America.

Legislation and Government Programs

In fiscal year 2008, the Defense Logistics Agency (DLA) suspended the public sales of tin pending additional study; DLA has sold no tin since then. The Annual Materials Plan (AMP) for fiscal year 2010 was set at 4,000 t of tin. The AMP for fiscal year 2011 was reduced to zero as tin was established as a "goal" material, to be held in reserve and was not available for sale. As of December 31, 2010, the tin inventory was 4,020 t, all of which was stored at the DLA's depot in Hammond, IN (K. Watt Lough, DLA Strategic Materials, written. commun., September 21, 2011).

On December 17, 2010, the "Reduction of Lead in Drinking Water Act" (Public Law 111–380) was passed by the U.S. Congress and was signed into law by the President on January 4, 2011. The law becomes effective January 4, 2014, allowing ample time for manufacturers to comply. The law lowers the national standard for lead in faucets, pipe fittings, and pipes to 0.25% from 8.0% and harmonizes lead standards across the country. Tin industry officials believed the lower lead standard could promote greater use of tin in plumbing fixtures because many fixtures are comprised of alloys of lead and tin. The new fixtures, pipes, and solders that join them were expected to be lower in lead, and higher in tin (Plumbing Manufacturers International, 2011).

Production

Mine.—Tin was not mined in the United States in 2010. Until 1993, a few small tin mines had operated sporadically in the United States; no tin mine production data have been reported to the U.S. Geological Survey (USGS) since that year.

Secondary.—The United States was the world's leading producer of secondary or scrap tin. Most secondary tin was generated during manufacturing processes from various scrapped alloys of tin and recycled in those same alloy industries. Secondary tin from recycled fabricated parts was used in many kinds of products and was a particularly important source of tin for the manufacture of brass, bronze, and solder.

Consumption

In 2010, domestic production from scrap was estimated to be 13,600 t, just slightly more than that in 2009 (table 5). Domestic consumption data for tin were developed by the USGS from a voluntary survey of tin consumers. Of the 110 firms to which a survey form was sent, 72 responded, including the major consumers. Data for the nonrespondents were estimated based on prior-year reporting.

The total number of metal cans shipped domestically was 130 billion in 2010 compared with 129 billion in 2009. Steel (essentially tinplate and tin-free steel) dominated in the food, pet, and general line can markets, and aluminum held 100% of the beverage can markets (Can Manufacturers Institute, 2011, p. 20).

Researchers at Purdue University (West Lafayette, IN) announced the development of a potential new tool for medical diagnostics, testing food and water contamination, and for use in crime scene forensics. The technique uses a combination of light and electric fields to position droplets on a specific region of a sensor so that particles such as bacteria, viruses, and DNA, which are contained inside the drops, can be analyzed. The technology features electrodes made of indium and tin oxide, is transparent and electrically conductive, and is used in consumer electronics in touch-screen displays (Venere, 2010).

Prices

The Platts Metals Week average composite price for tin metal increased by 48% from that in 2009. Industry observers attributed the significant price increase to a rebound in consumption following the 2008–09 world economic crisis, restocking, continued growth in consumption in several of the world's developing economies, and the role played by the world's investment funds. The London Metal Exchange Ltd. remained the principal trading site for tin.

Foreign Trade

U.S. imports of refined tin, which supplied most domestic tin requirements, increased by 7% compared with those of 2009 (table 8). Imports of tin in all forms (metal, ore and concentrate, scrap, and waste) remained duty free, and were held in U.S. warehouses by trading firms until sold to customers. Foreign-owned trading firms tended to dominate the marketing of imports. U.S. imports of tin came mostly from Peru, Bolivia, Malaysia, and Indonesia, in descending order. Refined tin exports were significantly less than imports (tables 6, 8).

World Review

Analysts at Société Générale (Paris, France) issued a report predicting that world tin demand would increase in 2010 based mostly on improved global sales for electronic items, with Government stimulus packages in China offering particular support. The analysts expected tin demand to increase by 8% to 9% during 2010, supported by growth in the Chinese domestic appliance market and the beginnings of demand recovery in Europe, Japan, and North America. A Chinese Government program aimed at stimulating replacement demand for household appliances in nine Provinces increased consumption in 2009. The global tin market recorded a surplus of 12,900 t in 2009, according to the World Bureau of Metal Statistics (American Metal Market, 2010c).

ITRI Ltd. (Frogmore, United Kingdom) signed an agreement with the International Conference on the Great Lakes Region to collaborate on tin traceability and due-diligence programs in central Africa. Both organizations are working to limit opportunities for armed groups in the region to benefit financially from the production and trade of minerals. New U.S. regulations on the trade of material from conflict zones were designed to require reporting on products derived from minerals from Congo (Kinshasa) and surrounding countries. The agreement initially would address traceability for columbite-tantalum (coltan), cassiterite, wolframite, or their derivatives (the raw materials for tantalum and niobium, tin, and tungsten, respectively), and gold (Davies, 2010).

According to the ITRI, the top 12 world producers of refined tin in 2010 were, in descending order:

1. Yunnan Tin Group Co., Ltd. (China)
2. PT Timah Tbk (Indonesia)
3. Malaysia Smelting Corp. (Malaysia)
4. Minsur S.A. (Peru)
5. Thailand Smelting and Refining Co. Ltd. (Thaisarco) (Thailand)
6. Liuzhou China Tin Group Co. Ltd. (China)
7. Yunnan Chengfeng Non-Ferrous Metals Co., Ltd. (China)
8. Empresa Metalúrgica Vinto (Bolivia)
9. Metallo Chimique N.V. (Belgium)
10. Geijiu Zi-Li Ltd. (China)
11. PT Koba Tin (Indonesia)
12. Jiangxi Nanshan Tin Co. Ltd. (China)

The ITRI's International Tin Conference held in Vancouver, British Columbia, Canada, in May included information on global tin supply and demand (CRU Tin Monitor, 2010b).

China has rapidly transformed from a large net exporter of tin to a net importer, with supply increasingly constrained by raw materials availability, despite increased recycling.

Tin consumption began to show signs of increasing in 2010. Global solder shipments in the first quarter of 2010 were 55% higher than in the first quarter of 2009. However, there were some concerns about tin use—there was a strong risk of substitutions in PVC stabilizers.

Investment in new mine production was moderate. Yunnan Tin Corp., Timah, Minsur, and Metals X Ltd. (East Perth, Western Australia, Australia) have made investments in future supply, and some new producers like JSC Syrymbet (Almaty, Kazakhstan) could start up within the next 2 years. However, most other projects discussed had not even reached the feasibility stage.

Artisanal mining and "conflict minerals," which account for one-half of current world tin mine supply, can be seen as a development opportunity and a means of breaking out of the poverty cycle for undeveloped countries. There was growing pressure from non-Government organizations and Governments to restrict tin supply from some sources, notably parts of Congo (Kinshasa), as part of the "conflict minerals" situation.

According to the most recent survey conducted by ITRI, global refined tin consumption was estimated to have increased by almost 13% in 2010 to 360,000 t. Industrial and electronic solders together accounted for almost 54% of refined tin demand, having grown by an estimated 22,300 t in 2010. Solder, primarily for electronic applications, has consistently accounted for more than 50% of the tin end-use market since 2005. The estimated world tin use figure suggests that tin consumption was higher than previously expected following the recent global financial crisis, with the 2010 figures approximately the same as those of 2006. The study indicated that China's tin use had reached a new record level of 147,000 t, although consumption in the rest of the world was about 25,000 t less than its 2006 peak. The ITRI estimated that the world's tin consumers used about 59,000 t of secondary (scrap) tin in 2009, and estimated that figure to have increased slightly to 60,000 t in 2010, with China accounting for more than 75% of the world total. The ITRI data came from 171 companies worldwide, representing more than 47% of estimated refined tin usage (Metal-Pages, 2011).

Australia.—Stellar Resources Ltd. (Melbourne, Victoria) raised $21 million, which was expected to be used to resume drilling at its Gourlays deposit on the west coast of Tasmania and to carry out resource evaluation work at the nearby Heemskirk project, which it jointly owns with Gippsland Ltd. (Claremont, Western Australia). Magna Mining NL (West Perth) signed an agreement with Troygold Investment Pty. Ltd. (Buddina, Queensland) to help develop a tin tailings project in Russia (ITRI Ltd., 2010e).

Venture Minerals Ltd. (Subiaco, Western Australia) announced that drilling at its Mt. Lindsay tin-tungsten project in Tasmania increased the estimates of contained tin by 28%. The latest resource included a series of zones in skarn mineralization, extending over a strike length of 3.9 kilometers. The drilling and resource estimate were completed in preparation for a prefeasibility study for which the firm was fully funded with $28 million in cash following a recent funding campaign. Venture estimated indicated tin reserves at Mt. Lindsay to be 6.2 Mt at a grade of 0.4% tin and inferred tin reserves to be 4.2 Mt at a grade of 0.4% tin (Mining Journal, 2010).

All the assets controlled by Van Dieman Mines Plc (North Sydney, New South Wales) have been put up for sale. The company filed for bankruptcy in February 2009 following continuing startup problems, and its major shareholder would not supply additional funds. The firm's Endurance and Scotia projects had a planned production capacity of 1,300 metric tons per year (t/yr) of tin-in-concentrate (CRU Tin Monitor, 2010a).

Consolidated Tin Mines Ltd. (North Cairns, Queensland) announced that it had been granted a mineral development license for the Windermere project by the Queensland government after a 2-year wait, enabling it to add that resource into its adjacent Mt. Garnet project near Cairns. Windermere has a reported resource of 2.1 Mt grading 0.55% tin, increasing Mt. Garnet's total resource to 7.3 Mt grading 0.60% tin. Consolidated acquired Windermere from Metals X's subsidiary Bluestone Nominees Pty. Ltd. in February 2008. A scoping study in July 2010 indicated that without the addition of the Windermere resource, a centralized Mt. Garnet plant would have the potential to process 700,000 t/yr of tin ore to produce 22,900 t of tin metal in concentrate (Platts Metals Week, 2010).

Metals X concluded the sale of 50% of its Tasmanian assets for $44 million to form a joint venture between its subsidiary Bluestone Mines Tasmania Pty. Ltd. (Renison Bell, Tasmania) and YT Parksong Australia Holding Pty. Ltd. (Yunnan Province, China). The joint venture was expected to operate as Bluestone Mines Tasmania Joint Venture Pty. Ltd. Metals X's Renison operations were operating at a production rate of 8,000 t/yr of tin-in-concentrate (ITRI Ltd., 2010b).

Bolivia.—Empresa Minera Huanuni (Oruro) began a tender process for the construction of a much larger tin concentrator that would increase ore throughput to 3,000 metric tons per day (t/d) from 1,200 t/d. The expansion plan was originally approved in 2009. The expansion project will require a $40 million investment, to be provided by the company that wins the tender and Government-owned mining organization Corporación Minera de Bolivia (La Paz). The Huanuni tin mine produced almost 10,000 t of tin-in-concentrate in 2009 and is estimated to be at least equal to that in 2010 (CRU Tin Monitor, 2010a).

EMV announced that work would be underway in September 2010 to install an Ausmelt tin smelter at its Vinto site, with completion due by August 2011 and startup expected by September 2011. The Vinto tin smelter produced 13,000 t of refined tin in 2010. Vinto selected the Ausmelt style of tin smelter to improve the efficiency of the smelting operation (ITRI Ltd., 2010f; Shahriari, 2010).

Canada.—Adex Mining Inc. (Toronto, Ontario) announced that it may start mining tin and indium at its Mount Pleasant property in southwestern New Brunswick. A decision on moving ahead with the mine, which would be North America's first new tin mine in several decades, was expected by yearend 2010 but hinged on signing an offtake deal. Adex ran a variety of pilot production programs in 2010. The company's preliminary economic assessment showed the site's north zone could produce 3,200 t/yr of tin, or about 1% of global supply, for about 12 years, while indium production could total about 40 t/yr or roughly 10% of the global supply. The mine could also produce about 4,000 t/yr of zinc (American Metal Market, 2010a).

China.—Yunnan Tin Group, the world's leading tin producer, announced plans to double tin ore throughput from its Laochang ore deposit to 3,000 t/d during the next 9 years. The company planned a three-stage process for the expansion of the Laochang field, its leading mine. The first stage would increase the mine's ore treatment rate to 1,500 t/d by 2012. The second-stage expansion would take output to 2,000 t/d by 2014, and the ultimate goal of 3,000 t/d would be achieved by 2019. Yunnan also planned to boost mine production by the development of Wuchangping project in Hunan Province. Yunnan produced 59,200 t of refined tin in 2010 (ITRI Ltd., 2010g).

China Tin Group Co. Ltd. (Liuzhou, Guangxi Province) planned to have a public offering of its shares early in 2011. Officials at Guangxi Nonferrous Metals Group Ltd. (Guangxi, Zhuang Province), which owned China Tin, stated that the parent company would include its own antimony, silver, tin, and zinc production assets in China Tin. The parent company would submit the public offering application to the China Securities Regulatory Commission in October 2010 and expected to raise up to $368 million through the public float. Simultaneously, Guangxi signed a series of agreements on overseas projects, mainly in southeast Asia, including establishing offices in Laos to explore for antimony, copper, gold, lead, potash, tin, and zinc. China Tin has the leading tin reserves in China (ITRI Ltd., 2010c).

Indonesia.—The Indonesian tin smelter consortium, Banka Belitung Timah Sejahtera PT (BBTS) (Pangkalpinang), announced that it expected its tin output to fall by 40% in 2010, to about 12,000 t owing to excessive rain. BBTS observed that the authorities continued to monitor independent tin miners, resulting in less tin ore to process (American Metal Market, 2010b). Timah announced production figures indicating that, increasingly, offshore tin mining was contributing more to its production. Timah produced 40,400 t of tin in 2010 (ITRI Ltd., 2010d).

Malaysia.—MSC, one of the world's leading tin smelters, issued a prospectus to list its shares on the Singapore Stock Exchange. Currently MSC is listed on the Bursa Malaysia (the Malaysian stock market). The stock offering proceeds were expected to be used to acquire plant machinery and to develop new mines through selective acquisition of suitable mining concessions or leases, as well as of mining projects and assets primarily in Indonesia and Malaysia. MSC operated two tin smelting facilities—Bangka Island (Indonesia) and Butterworth (Penang). The Butterworth operation has a production capacity of about 35,000 t/yr of refined tin, and the Bangka operation has a capacity of 25,000 t/yr of refined tin. MSC was a 75%-owned subsidiary of The Straits Trading Co., Ltd. (Singapore), which is listed on the Singapore Stock Exchange (Platts Metals Week, 2011).

Morocco.—Kasbah Resources Ltd.'s (South Perth, Western Australia, Australia) Achmmach tin project in Morocco was reportedly on track toward the completion of a prefeasibility study on bulk underground mining of the deposit in the second quarter of 2011. The mine was expected to produce 6,000 t/yr of tin-in-concentrate during a phase I mine life of 6 years, based on the mining of 800,000 t/yr of ore grading 1% tin. A drilling program continued to firm up the resource toward a target of 10 Mt. As of August 2010, the inferred and indicated resource was 7 Mt with a grade of 0.8% tin. Kasbah Resources may use open pit mining for some shallow deposits (ITRI Ltd., 2010a).

Russia.—Novosibirsk Integrated Tin Works (NOK) (Novosibirsk), Russia's sole refined tin producer, sought to declare bankruptcy. Reportedly NOK's total debt was $38 million, of which more than one-third was overdue. NOK's refined tin production has steadily declined to very low levels in recent years, as most tin mines in Russia have closed. (CRU International Ltd., 2010).

Spain.—Solid Resources Ltd. (Sherwood Park, Alberta, Canada) announced that Spain's Ministry of Industry, Tourism, and Trade would cover 20% of the cost of the 2010 exploration program at the Doade-Presqeira property in the northwestern corner of Spain, which was the maximum allowable. Earlier drilling in 2003–05 identified lithium, tantalum, and tin in potentially economic quantities (ITRI Ltd., 2010f).

United Kingdom.—Wolf Minerals Ltd. (West Perth, Western Australia, Australia) continued progress at its Hemerdon Ball tungsten and tin project in Devon. Recent activity included metallurgical test work to confirm the process flowsheet design, plant design, engineering work, and drilling of six water monitoring bores to determine the hydrogeology of the ore body. Wolf planned a 3-million-metric-ton-per-year processing plant for the project, which officials anticipated could result in production of 500 t/yr of tin-in-concentrate (Wolf Minerals Ltd., 2010).

Outlook

Demand for primary tin worldwide was expected to increase moderately in the near term, at a rate of about 3% per year. That rate, however, could increase in a few years if new applications continue to find acceptance in the marketplace. Higher tin prices such as those that have prevailed in recent years, limit use in new applications.

World tin reserves appeared to be adequate to meet foreseeable demand. Secondary sources of tin were likely to remain an important component of supply, especially in the United States. The August 2008 cessation of tin sales from the National Defense Stockpile, unless revised, would end tin supply from this source. Domestic tin requirements were expected to continue to be met primarily through imports.

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TABLE 1
SALIENT TIN STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Production, secondary, contained tin[e]	metric tons	11,600	12,200	11,700	11,100	10,900
Exports, refined tin	do.	5,490	6,410	9,800	3,170	5,630
Imports for consumption, refined tin	do.	43,300	34,600	36,300	33,000	35,300
Consumption, contained tin:						
Primary	do.	29,200	23,700	23,100	24,800 [r]	25,300
Secondary	do.	8,480	7,490	6,250	7,750	4,820
Stocks, yearend, U.S. industry, contained tin	do.	7,890	9,100	8,560	7,070 [r]	6,410
Prices, average, contained tin:						
New York, NY, market	cents per pound	419.49	679.50	864.53	641.62	954.13
Platts Metals Week composite	do.	565.12	899.48	1,128.97	837.08	1,239.64
London, United Kingdom	do.	398.00	659.05	836.76	615.15	925.15
Kuala Lumpur, Malaysia	do.	397.69	658.42	837.70	609.34	922.17
World, production, contained tin:						
Mine	metric tons	293,000 [r]	303,000 [r]	257,000	264,000 [r]	265,000 [e]
Smelter:						
Primary	do.	320,000	327,000	316,000 [r]	323,000 [r]	333,000 [e]
Secondary	do.	19,000 [r]	18,500 [r]	17,900 [r]	17,200 [r]	17,100 [e]
Undifferentiated	do.	50	--	--	--	--

[e] Estimated. [r] Revised. do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits, except prices.

TABLE 2
U.S. CONSUMPTION OF PRIMARY AND SECONDARY TIN[1]

(Metric tons of contained tin)

	2009	2010
Stocks, January 1[2]	8,940	6,210
Net receipts during year:		
Primary	26,200	25,100
Secondary	5,930 [r]	2,910
Scrap	2,170	1,920
Total receipts	34,300	29,900
Total available	43,200	36,100
Tin consumed in manufactured products:		
Primary	24,800 [r]	25,300
Secondary	7,750	4,820
Total	32,600	30,100
Intercompany transactions in scrap	285	1
Total processed	32,900	30,100
Stocks, December 31 (total available less total processed)	10,300	6,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes tin in transit in the United States.

TABLE 3
U.S. CONSUMPTION OF TIN, BY FINISHED PRODUCT[1]

(Metric tons of contained tin)

	2009			2010		
Product	Primary	Secondary	Total	Primary	Secondary	Total
Alloys, miscellaneous[2]	1,960	W	1,960	2,460	W	2,460
Babbitt	291 [r]	31	322 [r]	288	W	288
Bar tin	245	--	245	W	W	W
Bronze and brass	950 [r]	1,250 [r]	2,200 [r]	1,230	1,240	2,460
Chemicals	9,290	W	9,290	9,470	W	9,470
Solder	5,110	W	5,110	3,880	3,460	7,340
Tinning	340	--	340	387	--	387
Tinplate[3]	6,130	--	6,130	6,920	W	6,920
Other[4]	532	6,470	7,000	684	127	811
Total	24,800 [r]	7,750	32,600	25,300	4,820	30,100

[r] Revised. W Withheld to avoid disclosing company proprietary data; included with "Other." -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes terne metal.

[3] Includes secondary pig tin and tin acquired in chemicals.

[4] Includes britannia metal, collapsible tubes and foil, jewelers' metal, pewter, tin powder, type metal, and white metal.

TABLE 4
U.S. INDUSTRY YEAREND TIN STOCKS[1]

(Metric tons)

	2009	2010
Plant raw materials:		
Pig tin:		
Virgin[2]	5,180 [r]	4,880
Secondary	571 [r]	164
In process[3]	856	857
Total	6,610 [r]	5,900
Additional pig tin:		
Jobbers-importers	266	319
Afloat to United States	190	190
Total	456	509
Grand total	7,070 [r]	6,410

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes tin in transit in the United States.

[3] Data represent scrap only, tin content.

TABLE 5

U.S. STOCKS, RECEIPTS, AND CONSUMPTION OF NEW AND OLD SCRAP AND TIN RECOVERED, BY TYPE OF SCRAP[1]

(Metric tons)

	Gross weight of scrap								
	Stocks,		Consumption			Stocks,	Tin recovered[e]		
Type of scrap	January 1	Receipts	New	Old	Total	December 31	New	Old	Total
2009:									
Copper-base scrap:									
Ingot makers	3,660	60,200	10,900	49,400	60,300	3,640	373	2,180	2,560
Brass mills[2]	--	W	W	W	W	--	1,170	W	1,170
Foundries and other plants	1,670	22,300 [r]	16,300 [r]	5,800 [r]	22,100 [r]	1,940 [r]	W	147 [r]	147 [r]
Total	XX	XX	XX	XX	XX	XX	1,550	2,330	3,870
Lead-base scrap	16,500	1,160,000	29,000	1,140,000	1,170,000	11,700	760	8,740	9,500
Tin-base scrap[3]	W	W	W	W	W	W	W	W	W
Grand total	XX	XX	XX	XX	XX	XX	2,310	11,100	13,400
2010:									
Copper-base scrap:									
Ingot makers	3,640	61,200	12,500	48,300	60,800	4,020	433	2,170	2,600
Brass mills[2]	--	W	W	--	W	--	1,400	W	1,400
Foundries and other plants	1,940	17,500	15,300	2,690	18,000	1,470	W	98	98
Total	XX	XX	XX	XX	XX	XX	1,830	2,270	4,100
Lead-base scrap	11,700	1,130,000	32,600	1,090,000	1,120,000	19,000	855	8,640	9,500
Tin-base scrap[3]	W	W	W	W	W	W	W	W	W
Grand total	XX	XX	XX	XX	XX	XX	2,680	10,900	13,600

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data. XX Not applicable. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Consumption is assumed to be equal to receipts.

[3] Includes tinplate and other scrap recovered at detinning plants.

TABLE 6

U.S. EXPORTS OF TIN IN VARIOUS FORMS[1]

	2009		2010	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ingots and pigs	3,170	$22,200	5,630	$35,900
Tin scrap and other tin-bearing material except tinplate scrap (gross weight)[2]	11,600	46,200	15,600	70,300
Tinplate and terneplate (gross weight)[2]	224,000	175,000	209,000	171,000

[1] Data are rounded to no more than three significant digits.

[2] Includes rods, profiles, flakes, tubes, and pipes.

Source: U.S. Census Bureau.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF TIN IN VARIOUS FORMS[1]

	2009		2010	
	Quantity (metric tons, gross weight)	Value (thousands)	Quantity (metric tons, gross weight)	Value (thousands)
Dross, skimmings, scrap residues, tin alloys, n.s.p.f.[2]	81,300	$23,400	58,000	$30,700
Miscellaneous[3]	XX	36,200	XX	53,200
Tin compounds	601	8,180	753	13,300
Tinplate and terneplate	295,000	366,000	464,000	500,000
Tinplate scrap	27,100	5,190	68,000	14,300

XX Not applicable.

[1] Data are rounded to no more than three significant digits.

[2] Not specifically provided for.

[3] Includes tinfoil, tin powder, flitters, metallics, and other manufactures n.s.p.f.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT TIN METAL, BY COUNTRY[1]

	2009		2010	
Country	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Belgium	82	$647	11	$241
Bolivia	6,300	82,300	6,060	120,000
Brazil	1,050	13,600	75	1,260
Canada	30	260	89	1,630
Chile	121	1,870	641	13,100
China	1,210	14,500	887	17,900
Germany	20	391	--	--
India	64	779	(2)	5
Indonesia	3,220	16,100	3,970	37,900
Japan	--	--	1	52
Malaysia	169	1,190	4,500	90,100
Peru	20,300	266,000	16,500	322,000
Singapore	451	5,650	996	18,100
Switzerland	25	382	1	11
Thailand	15	158	1,310	30,900
United Kingdom	(2)	7	(2)	11
Vietnam	--	--	225	4,020
Other	1	5	(2)	5
Total	33,000	404,000	35,300	658,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9

TIN: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010[e]
Australia	1,478	2,071	1,783	5,630 [r]	7,000
Bolivia	18,444	15,972	17,318 [r]	19,575 [r]	20,190 [3]
Brazil	9,528	11,835	11,000 [r]	10,000 [r]	11,000 [p]
Burma[4]	923	830	741	672	672 [3]
Burundi	46	2	21	20 [r, e]	20
China[e]	126,000	146,000	110,000	115,000	120,000
Congo (Kinshasa)[e]	3,800	8,900	12,300 [r]	10,000 [r]	6,700
Indonesia	80,933	66,137	53,228	55,000 [e]	56,000
Laos	650 [r]	570 [r]	690 [r]	350 [r]	300
Malaysia	2,398	2,263	2,605	2,412 [r]	1,769 [3]
Mexico	25	25	15	-- [r]	--
Niger[e]	13	11	10	-- [r]	--
Nigeria[e, 5]	1,400	180	185	183 [r]	180
Peru	38,470	39,019	39,037	37,503	33,848 [3]
Portugal	25	41	29	30 [e]	30
Russia[e]	3,000	2,500	1,500	1,200	1,100
Rwanda	390	740	980	850 [e]	900
Thailand	190	122 [r]	215 [r]	153 [r]	150
Uganda	2	2	2	2 [e]	2
Vietnam[e]	5,400 [r]	5,400 [r]	5,400 [r]	5,400 [r]	5,500
Total	293,000 [r]	303,000 [r]	257,000	264,000 [r]	265,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 12, 2011.

[3] Reported figure.

[4] Includes content of tin-tungsten concentrate.

[5] Concentrate gross weight reported, estimated 62% tin content.

TABLE 10

TIN: WORLD SMELTER PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010[e]
Australia:					
Primary	572	118	170	7,637	3,000
Secondary[e]	400	400	400	400	400
Total[e]	972	518	570	8,037	3,400
Belgium, secondary[e]	6,000	5,000	5,000	5,000	5,000
Bolivia, primary	14,089	12,251	12,666	14,995 [r]	14,975 [3]
Brazil:					
Primary	8,780	9,384	10,308	10,550	11,000
Secondary[e]	250	250	250	250	250
Total	9,030	9,634	10,558	10,800	11,300
Bulgaria, secondary[e]	10	10	10	10	10
Burma, primary[e]	30	30	30	30	30
China, primary[e]	132,000	149,000	140,000 [r]	140,000 [r]	150,000
Czech Republic, secondary[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Denmark, secondary[e]	100	100	75	75	75
Greece, secondary[e]	100	100	75	75	60
Indonesia, primary	65,357	64,127	53,417	54,000	55,000
Japan, primary	854	879	986	757 [r]	780
Malaysia, primary	22,850	25,263	31,630	36,407	38,737 [3]
Mexico, primary	25	25	15	15	--
Norway, secondary[e]	50	50	50	50	50
Peru, primary	40,495	36,004	38,865	34,503 [r]	36,451 [3]
Russia:[e]					
Primary	4,980	3,800	2,000	1,700	1,400
Secondary	500	400	300	300	300
Total	5,480	4,200	2,300	2,000	1,700
Rwanda	50	--	--	--	-- [3]
Spain, secondary[e]	10	10	10	10	10
Thailand, primary	27,540	23,104	21,860	19,423 [r]	19,000
United States, secondary	11,600	12,200	11,700	11,100	10,900 [3]
Vietnam, primary	2,665	3,369	3,583 [r]	3,046	3,000
Grand total	339,000 [r]	346,000 [r]	333,000 [r]	340,000 [r]	350,000
Of which:					
Primary	320,000	327,000	316,000 [r]	323,000 [r]	333,000
Secondary	19,000 [r]	18,500 [r]	17,900 [r]	17,200 [r]	17,100
Undifferentiated	50	--	--	--	-- [3]

[e]Estimated. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Whenever possible, total output has been separated into primary (from ores and concentrates) and secondary (tin metal recovered from old scrap). This table reflects metal production at the first measurable stage of metal output. Table includes data available through July 12, 2011.

[3] Reported figure.

TITANIUM

By Joseph Gambogi

Domestic survey data and tables were prepared by Elsie D. Isaac, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

Although import dependent on titanium mineral concentrates and titanium sponge, the United States continued to be a net exporter of titanium dioxide (TiO_2) pigment and wrought titanium metal products. Improving global economic conditions caused domestic production of TiO_2 pigment to increase by 7% compared with that of 2009. After declining in 2009, demand for titanium metal from the commercial aerospace industry rebounded, resulting in increased domestic production of titanium ingot and mill products. U.S. consumption of titanium used in steel and other alloys increased by 25% from that in 2009.

World production of TiO_2 contained in titanium mineral concentrates increased by 13% compared with that of 2009. The leading sources of imports of titanium mineral concentrates were Australia, Canada, and South Africa. Global TiO_2 pigment production capacity was estimated to be 5.7 million metric tons per year (Mt/yr).

Legislation and Government Programs

The Defense Advanced Research Projects Agency (DARPA) continued to fund work on low-cost extraction of titanium metal from oxide ores. DARPA efforts were aimed at producing high-quality titanium at a cost of less than $8.81 per kilogram. In fiscal year (FY) 2010, the DARPA program demonstrated production of commercially pure titanium at a rate of 500 pounds per day. In FY 2011, DARPA planned to demonstrate consolidation of titanium powder without using conventional melting techniques (Defense Advanced Research Projects Agency, 2011, p. 154).

Oak Ridge National Laboratory (ORNL), a science and technology laboratory managed for the U.S. Department of Energy by UT-Battelle, LLC, was developing methods to consolidate new and conventional titanium powders into net shape components. ORNL hoped to reduce the scrap generation and energy consumption during the fabrication of titanium components (Muth, 2011).

In 2010, two U.S. Department of Defense (DOD) programs were underway to improve the supply of titanium metal. Under a Title III agreement, International Titanium Powder (ITP) (a subsidiary of Cristal Global) was working with DOD to produce low-cost metallic titanium powder. Title III of the Defense Production Act (50 U.S.C. App. 2061 et seq.) is a program specifically designed to establish, expand, maintain, or modernize industrial capabilities required for national defense. Instead of sponge produced by magnesium reduction via the Kroll process, ITP planned to produce titanium metal powder by sodium reduction via the Armstrong process. ITP completed construction of a new 2,000-metric-ton-per-year (t/yr) plant in Ottawa, IL, and was expected to begin production in 2011 (Metal-Pages, 2010b). A second Title III effort was aimed at reducing cost and shortening delivery lead times for structural titanium and titanium armor. The initial goal of the second program was to direct roll titanium in widths and thicknesses that could be used for armor tiles on military ground vehicles (U.S. Department of Defense, 2011, p. 72).

Production

Titanium industry data for this report are collected by the U.S. Geological Survey (USGS) from annual and quarterly surveys of domestic titanium operations. In 2010, the USGS annual survey canvassed titanium mineral and pigment production operations. The two producers of titanium mineral concentrates responded, but data were withheld to avoid disclosing company proprietary information. Of the six active domestic TiO_2 pigment operations, four responded. Production from the operations that did not respond were estimated on the basis of prior year production levels and industry trends. Production of titanium ingot and mill products was aggregated from a quarterly survey of producers.

Mineral Concentrates.—Titanium mineral concentrates of economic importance include ilmenite, leucoxene, rutile, synthetic rutile, and titaniferous slag. Mining of titanium minerals is usually performed using surface methods. Dredging and dry mining techniques are used for the recovery of heavy minerals. Gravity spirals are used to separate the heavy-mineral suite, while magnetic and high-tension separation circuits are used to separate the heavy-mineral constituents. Ilmenite is often processed to produce a synthetic rutile or titaniferous slag. Although numerous technologies are used to produce synthetic rutile, nearly all are based on either selective leaching or thermal reduction of iron and other impurities in ilmenite. Titaniferous slag with a TiO_2 content of 75% to 95% is produced commercially using pyrometallurgical processes.

U.S. mineral concentrate producers were DuPont Titanium Technologies [a subsidiary of E.I. du Pont de Nemours and Co. (DuPont)] and Iluka Resources, Inc. (a subsidiary of Iluka Resources Ltd.). DuPont's mining operations near Starke, FL, produced a mixed product containing ilmenite, leucoxene, and rutile that was used as a feedstock in DuPont's TiO_2 pigment plants. In 2010, Iluka produced titanium mineral concentrates from its heavy-mineral operations near Stony Creek, VA.

A drilling program was underway at Cardero Resource Corp.'s Titac and Longnose deposits near Duluth, MN. Longnose and Titac are oxide-bearing ultramafic intrusions that contain disseminated, semimassive, and massive titanium-iron oxide mineralization. The intrusions are primarily composed of dunite, peridotite, and pyroxenite, and contain about 15% to 40% titanium-iron oxides. Drilling was expected to be completed in 2011 along with an updated resource estimate (Cardero Resource Corp., 2010).

DuPont extended the mine life of its Starke operation beyond 2017 through the acquisition of a 788 hectare parcel of timberland in Baker County from the Cummer Land Trust. DuPont has produced heavy-mineral concentrates from deposits along the Trail Ridge ore body since 1949 (Szakonyi, 2010).

Metal.—Commercial production of titanium metal involves the chlorination of titanium-containing mineral concentrates to produce titanium tetrachloride ($TiCl_4$), which is reduced with magnesium (Kroll process) or sodium (Hunter process) to form a commercially pure form of titanium metal. As the metal is formed, it has a porous appearance and is referred to as sponge. Titanium ingot and slab are produced by melting titanium sponge or scrap or a combination of both, usually with various other alloying elements such as aluminum and vanadium. Electron beam (EB), plasma arc melt (PAM), scull, and vacuum-arc remelting (VAR) are the commercial methods used to produce ingot and slab. Titanium mill products are produced from the drawing, forging, and rolling of titanium into products of various sizes and shapes. These mill products include billet, pipe and tube, plate, rod and bar, sheet, strip, and wire. Titanium castings are produced by investment casting and rammed graphite mold casting. Ferrotitanium is usually produced by induction melting of titanium scrap with iron or steel, but may be produced through the aluminothermic reduction of ilmenite. The two standard grades of ferrotitanium that are normally produced contain 40% and 70% titanium. Domestic ferrotitanium capacity was estimated to be 17,300 t/yr.

In 2010, U.S. producers of titanium sponge were Allegheny Technologies Inc. (ATI), Honeywell Electronic Materials Inc., and Titanium Metals Corp. (Timet). ATI's Rowley, UT, plant and Timet's Henderson, NV, plant produced titanium sponge using the Kroll process. Honeywell Electronic Materials' plant in Salt Lake City, UT, produced titanium sponge using the Hunter process and supported the company's production of electronic-grade titanium. Data on domestic production of titanium sponge were withheld to avoid disclosing company proprietary data (table 2). Owing to increased demand from the commercial aerospace industry, U.S. production of titanium ingot and mill products increased significantly in 2010 (table 3). U.S. producers of ferrotitanium were RTI International Metals Inc. (Canton, OH) and Global Titanium Inc. (Detroit, MI). Data on production of ferrotitanium were not available.

TiO_2 Pigment.—TiO_2 pigment is produced from titanium mineral concentrates by either the chloride process or the sulfate process. In the chloride process, rutile is converted to $TiCl_4$ by chlorination in the presence of petroleum coke. $TiCl_4$ is oxidized with air or oxygen at about 1,000° C, and the resulting TiO_2 is calcined to remove residual chlorine and any hydrochloric acid that may have formed in the reaction. Aluminum chloride is added to the $TiCl_4$ to assure that virtually all the titanium is oxidized into the rutile crystal structure. In the sulfate process, ilmenite or titanium slag is reacted with sulfuric acid. Titanium hydroxide is then precipitated by hydrolysis, filtered, and calcined. Although either process may be used to produce pigment, the decision of which process to use is based on numerous factors, including raw material availability, freight, and waste disposal costs. In finishing operations, the crude form of the pigment is milled to produce a controlled distribution of particle size and surface treated or coated to improve its functional behavior in different media. Some typical surface treatments include alumina, organic compounds, and silica.

TiO_2 pigment produced by either process is categorized by crystal form as either anatase or rutile. Rutile pigment is less reactive with the binders in paint when exposed to sunlight than is the anatase pigment and is preferred for use in outdoor paints. Anatase pigment has a bluer tone than rutile, is somewhat softer, and is used mainly in indoor paints and in paper manufacturing. Depending on the manner in which it is produced and subsequently finished, TiO_2 pigment can exhibit a wide range of functional properties, including dispersion, durability, opacity, and tinting.

U.S. production of TiO_2 pigment was 1.32 million metric tons (Mt) in 2010, a 7% increase compared with that in 2009 (table 5). U.S. producers of TiO_2 pigment by the chloride process were Cristal Global, DuPont, Louisiana Pigment Co. L.P. (a joint venture of NL Industries, Inc. and Huntsman Corp.), and Tronox Inc. (table 4). TOR Minerals International, Inc. produced a buff TiO_2 pigment from finely ground synthetic rutile.

Consumption

Mineral Concentrates.—On a gross weight basis, 95% of the domestic consumption of titanium mineral concentrates was used to produce TiO_2 pigment. The remaining 5% was used to produce miscellaneous other products, including fluxes, metal, and welding rod coatings. Based on TiO_2 content, domestic consumption of titanium mineral concentrates was 1.46 Mt, an 8% increase compared with that of 2009 (table 6). Consumption data for titanium concentrates were estimated by the USGS owing to insufficient response by industry to the voluntary survey for consumption data.

Metal.—Titanium metal alloys are used for their high strength-to-weight ratio and corrosion resistance. In general, production of titanium mill products precede aircraft deliveries by about 1 year. In 2010, mill product shipments increased by 62% because of increased aircraft build rates and higher inventory levels throughout the titanium supply chain (table 3). The aerospace industry (67%) was the leading end use for mill products. Other uses included those in the consumer goods, marine, medical, oil and gas, pulp and paper, and specialty chemical industries.

A significant quantity of titanium in the form of ferrotitanium, scrap, and sponge is consumed in the steel and nonferrous alloy industries. In the steel industry, titanium is used for deoxidation, grain-size control, and controlling and stabilizing carbon and nitrogen content. Titanium-intensive steels include interstitial-free, stainless, and high-strength low-alloy steels. Reported domestic consumption of titanium products in steel and other alloys was 11,700 t, a 25% increase compared with that of 2009 (table 7). Increased demand from the specialty steel industry resulted in an increase in ferrotitanium consumption.

TiO_2 Pigment.—Owing to increased global consumption, domestic production of TiO_2 pigment increased by 7% while domestic consumption increased slightly compared with that of 2009 (table 5). The leading uses of TiO_2 pigment, based on TiO_2 pigment shipments in the United States, were paint and coatings

(57.1%), plastics and rubber (27.4%), and paper (9.7%). Other uses (5.8%) included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules (table 8).

Stocks

Insufficient data were available to determine yearend consumer inventories of titanium mineral concentrates and TiO_2 pigment producer stocks. Owing to increased consumption by the aerospace and steel industries, yearend domestic stocks of sponge decreased by 32% compared with those in 2009. Because titanium metal producers anticipated increased consumption, domestic stocks of ingot increased by 9% in 2010 (table 3).

Prices

Yearend titanium mineral concentrate prices are listed in table 9. Owing to increased demand from TiO_2 pigment producers, prices for bulk ilmenite and rutile concentrates were higher compared with prices in 2009. Published prices for titanium slag were not available. Based on U.S. Customs Service data, the yearend unit value of slag imports ranged from \$367 to \$433 per metric ton in 2010 compared with \$401 to \$439 per ton in 2009.

The U.S. Department of Labor, Bureau of Labor Statistics, yearend producer price index (PPI) for TiO_2 pigment increased by 18% compared with that of 2009. The monthly PPI started the year at 165, was nearly unchanged at midyear, and then rose to 194 by yearend (U.S. Department of Labor, Bureau of Labor Statistics, 2011).

A resurgence in demand from aircraft programs and an improving global economy caused prices of titanium mill products to rise. At yearend, the monthly PPI for titanium mill products reached a high of 203. Sponge and ingot prices were less affected by short-term demand because of long-term contracts (U.S. Department of Labor, Bureau of Labor Statistics, 2011).

Foreign Trade

Mineral Concentrates.—Imports of titanium mineral concentrates include ilmenite, rutile, synthetic rutile, and titaniferous slag. The United States was heavily reliant on imports of titanium mineral concentrates because domestic consumption of titanium minerals greatly exceeded domestic production capacity. In 2010, the TiO_2 content of imports was estimated to be 966,000 t, primarily in the form of titaniferous slag (42%) and ilmenite (24%). South Africa, Australia, Canada, and Mozambique were, in descending order of TiO_2 quantity, the leading import sources. The combined value for all forms of titanium concentrate imports in 2010 was \$442 million (table 11). Because of increased steel production, imports of titaniferous iron ore from Canada, classified as ilmenite by the U.S. Census Bureau, increased significantly. Exports of titanium concentrates were minor relative to imports (tables 10–11).

Metal.—Total imports of titanium metal increased significantly in 2010. Imports of titanium metal were primarily in the form of sponge (51%), waste and scrap (27%), and wrought products and castings (22%). Japan and Kazakhstan were the leading sources of imported titanium sponge, while Germany, the United Kingdom, Japan, and France were, in descending order, the leading sources of imported scrap. Germany supplied two-thirds of the imported titanium ingot, and China was the major source of titanium powder. Imports of powder and other unwrought forms of titanium increased significantly compared with those of 2009.

Imports of titanium wrought products and castings were primarily in the form of plate, sheet, strip, and foil (38%); bar, rod, profiles, and wire (29%); and billets (23%). Russia was the leading source of wrought products and castings. Imports of wrought products and castings increased to a record high 8,710 t. Owing to increased consumption of titanium for steel and other alloys, imports of ferrotitanium were 2,740 t, an 8% increase compared with those of 2009. The leading import sources were, in descending order, the United Kingdom, Russia, and Canada. Exports of ferrotitanium were 2,570 t, a 27% increase compared with those of 2009.

TiO_2 Pigment.—The United States continued to be a net exporter of TiO_2 pigment. In 2010, exports exceeded imports by a ratio of 3.7 to 1. Exports of TiO_2 pigment were 758,000 t, a 17% increase compared with those of 2009. About 95% of TiO_2 pigment exports was in the form of finished pigment with 80% or more TiO_2 content.

During 2010, 204,000 t of TiO_2 pigment was imported, a 17% increase compared with that in 2009. The leading import sources of TiO_2 pigment were Canada (39%) and China (12%). About 71% of pigment imports was in the form of finished pigment with more than 80% TiO_2 (table 13).

In November, the United States Bankruptcy Court for the Southern District of New York approved a reorganization plan for Tronox Inc. that would allow the company to emerge from Chapter 11 of the U.S. Bankruptcy Code. Under the plan, Tronox agreed to pay \$270 million to settle certain environmental liabilities as well as 88% of proceeds from pending litigation. Global TiO_2 production capacity for Tronox was 390,000 t/yr with operations in Hamilton, MS; Botlek, Netherlands; and Kwinana, Australia (50% ownership) (PRNewswire-FirstCall, 2010). In 2009, Tronox had idled its 110,000-t/yr TiO_2 operation in Savannah, GA.

World Review

Australia.—In August, the mining license for Astron Ltd.'s Donald mining project was approved by the Department of Primary Industries, Victoria, and mine and plant designs were completed during the year. Ore reserves were estimated to be 305 Mt, with 6.3% heavy minerals containing 32% ilmenite, 19% leucoxene, and 4.4% rutile (Astron Ltd., 2010a, b).

Diatreme Resources Ltd. was conducting exploration and prefeasibility studies on its heavy-mineral deposits in the Eucla Basin, Western Australia. The resource estimated for its Cyclone deposit was 3.1 Mt of heavy minerals with 1.32 Mt classified as measured and 1.59 Mt classified as indicated (Diatreme Resources Ltd., 2011, p. 6).

Gunson Resources Ltd. completed a definitive feasibility study for its Coburn heavy-minerals project in Western Australia. Reserves of heavy minerals including ilmenite, leucoxene, rutile, and zircon in the Coburn deposit were estimated to be 3.7 Mt supporting a mine life of 17 years, with a production rate of 146,000 t/yr (Gunson Resources Ltd., 2010, p. 5–9).

Owing to increased demand for titanium minerals, Iluka significantly increased its production of ilmenite and rutile in Australia (250,000 t in 2010 compared with 141,000 t in 2009). The company's Australian ilmenite production also increased (218,000 t in 2010 compared with 159,000 t in 2009). Synthetic rutile production declined significantly (348,000 t in 2010 compared with 405,000 t in 2009) following Iluka's decision to idle two of four synthetic rutile kilns in Western Australia. The increases were largely because of the ramp up of its new operations in the Eucla Basin, South Australia, and the Murray Basin, Victoria. In 2010, Iluka's exploration and development efforts focused on the Eucla and Murray Basins and increased Iluka's mineral resource estimate of heavy minerals by 7.3 Mt (Iluka Resources Ltd., 2011, p. 3–4, 17–18).

Matilda Zircon Ltd. continued to develop heavy-minerals deposits in the Northern Territory and Western Australia. In 2010, Matilda Zircon formed an agreement with China-based Tricoastal Minerals Co. to take all heavy-mineral concentrate from the Tiwi Islands operations and supply $2.5 million in loans and share placements to assist in development of the Lethbridge Mine, which began production in June. At yearend, the company expected approval from the Western Australian Minister of the Environment to proceed with the development of the Keysbrook deposit, 70 kilometers south of Perth. Mining at Keysbrook was expected to begin in 2012, with an 8-year mine life (Matilda Zircon Ltd., 2010, p. 8–11).

Owing to increasing demand for TiO_2 pigment, the Western Australia-based joint venture, Tiwest Pty Ltd., commissioned a 40,000-t/yr expansion project at its Kwinana TiO_2 pigment plant, raising production capacity to 150,000 t/yr. Tiwest operated the joint venture between Tronox Western Australia Pty Ltd. (50%) and subsidiaries of Exxaro Australia Sands Pty Ltd. (50%) (Exxaro Resources Ltd., 2011, p. 53).

Canada.—Titanium Corp. continued its research into the recovery of bitumen, volatile organic compounds, and heavy minerals, including ilmenite and leucoxene, from mined oil sand tailings. In 2010, Titanium Corp. commissioned a demonstration pilot plant at the Canadian Government's Canmet testing facilities in Devon, Alberta. Pilot studies were conducted during June through September, with additional studies planned for 2011 (Titanium Corp., 2010, p. 4).

In Quebec, Argex Mining Inc. was proceeding with exploration and development of its La Blache titaniferous magnetite project near Bai-Comeau. In 2010, Argex contracted with Met-Chem Canada Inc. to complete a resource estimate and with Process Research Ortech Inc. to develop a commercial process for the recovery of TiO_2. Argex contracted with Groupe BBA Inc. in preparation for a scoping study to evaluate the requirements for mining and milling operations, metallurgical processing facilities, and infrastructure. In 2010, a total of 20,300 meters were drilled on the La Blache Property (Argex Mining Inc., 2011, p. 2–3).

Chile.—White Mountain Titanium Corp. (WMT) was proceeding with the exploration and development of its Cerro Blanco rutile deposit. In 2010, WMT conducted drilling and pilot-plant feasibility studies. In 2011, WMT was scheduled to conduct a final engineering feasibility study to support the development of a 5 to 6 Mt/yr mining operation for 20 years (White Mountain Titanium Corp., 2010).

China.—China's titanium metal and pigment production capacity continued to rise. According to the Chinese Titanium Association, the top 14 sponge producers increased sponge production capacity to 103,500 t/yr in 2010 and sponge production reached 57,800 t, up 42% from that in 2009. China's ingot (89,200 t/yr) and mill product (38,300 t/yr) production capacity also increased substantially (Zou, 2011). China's TiO_2 production and consumption was reported to have reached record levels in 2010. Production was 1.47 Mt, compared with 1.05 Mt in 2009, and domestic consumption was more than 1.4 Mt (Paint & Coatings Industry, 2011).

Although the development of domestic mine production was ongoing, increased consumption of titanium concentrates was met through increased imports of titanium mineral concentrates. In 2010, Chinese imports of titanium mineral concentrates nearly doubled to 2.04 Mt from 1.07 Mt in 2009. The unit value of imports was $126 per metric ton compared with $110 per metric ton in 2011 (United Nations Statistics Division, undated).

China's National Development and Reform Commission approved Panzhihua Iron Steel Group to develop vanadium and titanium resources and increasing processing titanium sponge and pigment capacity in Sichuan Province. Panzhihua planned to increase production capacity of titanium mineral concentrates to 500,000 t/yr, TiO_2 pigment to 200,000 t/yr, and titanium sponge to 15,000 t/yr (Steelguru.com, 2011).

Germany.—In May, Tronox Pigments GmbH changed its name to crenox GmbH. Sulfate-route TiO_2 production capacity at the Krefeld-Uerdingen operation was 107,000 t/yr (crenox GmbH, 2010).

India.—In June, Kerala Minerals & Metals Ltd. (KMML) produced the first batch of titanium from its new 500-t/yr sponge plant, the country's first commercial sponge plant. $TiCl_4$ was supplied to the plant from KMML's Chavara TiO_2 pigment plant. KMML also reported it had commissioned the country's first commercial nano-TiO_2 plant and a titanium oxychloride pilot plant (Kerala Minerals & Metals Ltd., undated).

Trimex Group continued its plan to produce up to 200,000 t/yr of ilmenite and 6,000 t/yr of rutile in the Srikurmam District, Andhra Pradesh. In 2010, Trimex completed the first phase of the Srikurmam project, including detailed engineering plans and finalizing the mining license agreement with the Government of India and private land owners (Trimex Sands Pvt. Ltd., 2010). Proven reserves were estimated to be 5.5 Mt of ilmenite (Industrial Minerals, 2008).

Japan.—Toho Titanium Co., Ltd. raised its overall sponge production capacity to 25,200 t/yr. Toho completed construction of a new 12,000-t/yr plant at Wakamatsu, Fukuoka Prefecture (Toho Titanium Co., Ltd., 2010). At its Chigasaki plant, Toho dismantled a portion of its production capacity that was deemed inefficient and reduced capacity to 13,200 t/yr from 16,000 t/yr (Toho Titanium Co., Ltd., 2011).

In August, OSAKA Titanium technologies Co., Ltd. resumed plans to increase capacity at its Amagasaki sponge plant to 38,000 t/yr (Japan Metal Bulletin, 2010). The expansion plan followed a series of capacity increases. In 2008, sponge production capacity had been raised to 32,000 t/yr from 24,000 t/yr at Amagasaki, and ingot capacity had been increased at its Kishiwada plant to 10,000 t/yr from 7,000 t/yr in 2009 (OSAKA Titanium technologies Co. Ltd., 2010).

Kazakhstan.—Ust-Kamenogorsk Titanium-Magnesium Plant (UKTMP), the sole producer of titanium sponge in Kazakhstan, commissioned new VAR ingot production capacity in eastern Kazakhstan. A 16,000-t/yr ingot plant producing both commercially pure and alloy ingot was commissioned in 2010. In 2008 and 2009, UKTMP formed joint ventures in Europe and Asia to produce titanium mill products for industrial and aerospace markets (Metal-Pages, 2010a).

Kenya.—In July, Base Resources Ltd. acquired the Kwale mineral sands project from Vaaldiam Mining Inc. and began updating a definitive feasibility study completed by Vaaldiam in 2006. The feasibility study, drilling program, and process design review were completed by yearend. By 2014, Base Resources planned to begin production of heavy-mineral concentrates with production capacity for 330,000 t/yr of ilmenite, 79,000 t/yr of rutile, and 30,000 t/yr of zircon (Base Resources Ltd., 2011, p. 10–12).

Madagascar.—QIT Madagascar Minerals SA (QMM) was ramping up production at its 700,000-t/yr mineral sands project near Mutamba. QMM was a joint venture between Rio Tinto plc (80%) and the Government of Madagascar (20%). In 2010, QMM produced 287,000 t of ilmenite and planned to produce 473,000 t in 2011 (McNeish, 2011).

Mozambique.—Kenmare Resources plc was increasing heavy-minerals production at its Moma operation to design capacity. In 2010, the Moma operation produced 678,000 t of ilmenite, a 44% increase compared with that of 2009, and rutile production was 4,700 t, a 161% increase compared with that in 2009. In October, a breach of a settling pond allowed water to flood into a nearby village, causing one fatality. The mine was idled for 4 weeks while repairs and new safety measures were implemented. At yearend, Kenmare was proceeding with an expansion plan that would increase production capacity by about 50% (Kenmare Resources plc, 2011, p. 13).

Norway.—Nordic Mining ASA was developing an rutile-bearing eclogite deposit at Engebøfjellet in Sogn and Fjordane County. In 2010, Nordic Mining received approval from the Norwegian Climate and Pollution Agency to sell tailings from its proposed Engebøfjellet operation as capping material for contaminated sediments (Nordic Mining ASA, 2010).

Russia.—ARZM Uranium Holding Co. continued to develop the Lukoyanovskoye heavy-minerals sands deposit near Nizhny Novgorod. By 2014, the company planned to begin production of heavy-mineral concentrates including up to 35,000 t/yr of ilmenite, and 5,000 t/yr of rutile (ARZM Uranium Holding Co., 2010, p. 40).

Owing to improving market conditions, VSMPO-AVISMA Corp. resumed plans to increase its titanium sponge production capacity to 44,000 t/yr by 2015. VSMPO also was proceeding with plans to increase its capacity to produce forged and mill products to 45,000 to 46,000 t/yr by 2015 (Interfax, 2010).

Senegal.—A feasibility study of Mineral Deposits Ltd.'s Grande Cote heavy-minerals deposit was completed in 2010, allowing the company to secure financing to develop the project. Construction of the mine and separation plants was expected to begin in 2011, and initial production was scheduled for 2013. Once the mine and separation plants are fully commissioned, the company expected to produce an average of 575,000 t/yr of ilmenite, 80,000 t/yr of zircon, 11,000 t/yr of leucoxene, and 6,000 t/yr of rutile (Mineral Deposits Ltd., 2010, p. 16).

Sierra Leone.—A strategic review of Titanium Resources Group Ltd. (TRG) plans to optimize and expand its production was underway and expected to be completed in 2011. In 2010, production was hindered by a fire on its dredge, downtime following a move of the wet separation plant, and problems with slimes in the dredge pond. In 2011, TRG expected its ilmenite and rutile production to be similar to that in 2010 (18,200 t of ilmenite and 63,900 t of rutile), but a significant increase in production was expected in 2012 following the completion of process improvements. Subsequent to yearend, TRG changed its name to Sierra Rutile Ltd. (Sierra Rutile Ltd., 2011, p. 6–7).

South Africa.—In October, a burn-through caused both slag furnaces at Exxaro Resources Ltd.'s KZN Sands operation to be idle for 2 months. Despite production lost to maintenance and repair, total slag production from Exxaro's KZN Sands and Namakwa Sands operation increased by 16% to 284,000 t. Exxaro's Hillendale Mine neared the end of its life; however, plans were underway to develop the Fairbreeze deposit as a substitute for the waning production from the Hillendale Mine (Exxaro Resources Ltd., 2011, p. 45, 53).

Rio Tinto invested $158 million in a tailings treatment facility at its Richards Bay Minerals heavy-minerals operation. At yearend, the treatment facility neared completion and was scheduled to begin production in the first quarter of 2011. Heavy-mineral concentrates, including ilmenite and rutile, were to be recovered from about 30 years accumulation of mine tailings (Industrial Minerals, 2010).

Ukraine.—Rutile-Ilmenite Co. (RICO) was planning to mine and process heavy-mineral sands at its deposit in Tarasovka. RICO planned to produce 51,000 t of heavy-mineral concentrates including ilmenite (6,000 t), leucoxene (20,000 t), rutile (15,000 t), and zircon (10,000 t) (Industrial Minerals, 2009).

Velta LLC announced plans to begin production at the Birzulvovske mining operation near Korobchino, Kirovograd Oblast in 2012. Initial capacity of the operation was expected to be 180,000 t/yr of ilmenite (Mineral Sands Report, 2010).

Vietnam.—In an effort to assist the domestic mining industry, the Government of Vietnam continued to suspend a ban on exports of titanium and zirconium mineral concentrates designed to encourage the production of value-added products. Producers were permitted to export through the end of 2010 (Mineral Sands Report, 2009).

Outlook

For the foreseeable future, the market for titanium minerals is expected to be driven by the production of TiO_2 pigment. Unless new mines are developed, the U.S. reliance on imports of titanium mineral concentrates is likely to increase as existing mines are expected to be depleted by 2020.

Global demand growth for TiO_2 is expected to track with the total global gross domestic product and the production of paint, paper, and plastics. Through 2020, higher-than-average growth is expected to continue in Asia. China, in particular, is expected to lead world growth in production and consumption of TiO_2. The International Monetary Fund (IMF) projected that world economic growth would be about 4.3% in 2011 and 4.5% in 2012. The IMF expected China to lead global economic growth with 9.6% in 2011 and 9.5% growth expected in 2012. China's continued growth was expected to significantly increase titanium mineral, pigment, and metal consumption during the long term. In the United States, the economy was projected to increase by 2.2% in 2011 and 2.6% in 2012 (International Monetary Fund, 2011). The U.S. Congressional Budget Office projected the long-term U.S. gross domestic product growth to average 3.6% per year from 2013 to 2016 (U.S. Congressional Budget Office, 2011).

Aerospace, defense, and industrial uses are expected to strongly influence consumption of titanium metal for the foreseeable future. Commercial aircraft production is expected to remain the dominant consumer of titanium metal. The growth of the global airplane fleet was projected to average 3.6% per year from 2010 to 2030 (Boeing Co., The, 2011, p. 4). According to one industry estimate, global consumption of titanium metal by the defense industry was expected to climb to 19,100 t by 2015 from 14,500 t in 2010 (Hickton, 2011, p. 20). Within the next 3 years, global titanium metal production was expected to increase in line with the construction of new aircraft and increased industrial output. Government and private industry programs may commercialize lower cost methods of producing titanium metal.

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TABLE 1
SALIENT TITANIUM STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Mineral concentrate:						
Imports for consumption	metric tons	1,230,000	1,460,000	1,380,000	943,000	1,200,000
Consumption[e, 2]	do.	1,870,000	1,950,000	1,780,000	1,700,000	1,820,000
Sponge metal:						
Imports for consumption	do.	24,400	25,900	23,900	16,600	20,500
Consumption	do.	28,400	33,700	W	W	34,900
Price, yearend[3]	dollars per pound	5.87–12.84	6.33–7.06	6.16–8.02	4.50–7.07	3.50–6.24
Titanium dioxide pigment:						
Production	metric tons	1,370,000	1,440,000	1,350,000	1,230,000	1,320,000
Imports for consumption	do.	288,000	221,000	183,000	175,000	204,000
Consumption, apparent	do.	1,080,000[4]	979,000[5]	800,000[5]	757,000[5]	767,000[5]
Producer price index, yearend[6]	(1982=100)	165	162	170	164	194
World, production:						
Ilmenite concentrate[7]	metric tons	6,860,000[r]	7,140,000[r]	6,970,000[r]	6,090,000[r]	6,870,000
Rutile concentrate, natural[8]	do.	516,000[r]	607,000[r]	634,000[r]	571,000[r]	710,000
Titaniferous slag[e]	do.	2,160,000	2,230,000	2,230,000	2,000,000	2,210,000

[e]Estimated. [r]Revised. do. Ditto. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits, except prices.

[2] Excludes consumption used to produce synthetic rutile.

[3] Landed duty-paid unit based on U.S. imports for consumption.

[4] Production plus imports minus exports plus stock decrease or minus stock increase.

[5] Production plus imports minus exports. Excludes stock changes.

[6] Source: U.S. Department of Labor, Bureau of Labor Statistics.

[7] Includes U.S. production of ilmenite, leucoxene, and rutile rounded to one significant digit to avoid disclosing company proprietary data.

[8] U.S. production of rutile included with ilmenite to avoid disclosing company proprietary data.

TABLE 2
U.S. TITANIUM METAL PRODUCTION CAPACITY IN 2010[1, 2]

(Metric tons per year)

Company	Plant location	Yearend capacity[e]	
		Sponge	Ingot[3]
Alcoa Howmet	Whitehall, MI	--	3,200
Allegheny Technologies Inc.	Albany, OR	(4)	10,900
Do.	Monroe, NC	--	23,200
Do.	Richland, WA	--	10,000
Do.	Rowley, UT	10,900	--
Alloy Works LLC	Greensboro, NC	--	1,800
Honeywell Electronic Materials Inc.	Salt Lake City, UT	500	--
Perryman Co.	Houston, PA	--	1,800
RTI International Metals, Inc.	Niles, OH	--	13,600
Titanium Metals Corp.	Henderson, NV	12,600	12,300
Do.	Morgantown, PA	--	40,700
Do.	Vallejo, CA	--	800
Total		24,000	118,000

[e]Estimated. Do. Ditto. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Estimated operating capacity based on 7-day-per-week full production.

[3] Includes electron-beam, plasma, and vacuum-arc-remelting capacity.

[4] In July 2009, sponge capacity of 9,980 metric tons per year was temporarily idled, and did not operate in 2010.

TABLE 3

COMPONENTS OF U.S. TITANIUM METAL SUPPLY AND DEMAND[1]

(Metric tons)

Component	2009	2010
Production:		
Ingot	35,600	56,400
Mill products	31,900	36,300
Exports:		
Waste and scrap	4,200	3,480
Sponge	820	293
Other unwrought	3,790	3,040
Wrought products and castings	12,500	14,800
Total	21,300	21,600
Imports:		
Waste and scrap	4,770	10,700
Sponge	16,600	20,500
Other unwrought	573	444
Wrought products and castings	6,930	8,720
Total	28,900	40,300
Stocks, industry, yearend:		
Sponge	15,300	10,500
Scrap	9,880	7,900
Ingot	2,680	2,920
Consumption, reported:		
Sponge	W	34,900
Scrap	25,700	29,200
Ingot	30,100	40,900
Shipments:		
Ingot	10,600	13,700
Mill products (net shipments):		
Forging and extrusion billet	9,520	19,700
Other	14,100 r	18,500
Total	23,700	38,300
Castings (shipments)	W	W
Receipts, scrap:		
Home	10,600	9,770
Purchased	17,700	23,400
Total	28,300	33,200

rRevised. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 4
U.S. PRODUCERS OF TITANIUM DIOXIDE PIGMENT IN 2010[1, 2, 3]

(Metric tons per year)

Company	Plant location	Yearend capacity[4]
Cristal Global	Ashtabula, OH	220,000
Du Pont Titanium Technologies	De Lisle, MS	340,000
Do.	Edgemoor, DE	154,000
Do.	New Johnsonville, TN	380,000
Louisiana Pigment Co. L.P.	Lake Charles, LA	146,000
Tronox Inc.	Hamilton, MS	225,000
Do.	Savannah, GA	(5)
Total		1,470,000

Do. Ditto.

[1] Estimated operating capacity based on 7-day-per-week full production.

[2] Table does not include TOR Minerals International, Inc.'s Corpus Christi, TX, production capacity of about 26,400 metric tons per year (t/yr) of buff TiO_2 pigment that is produced by refining and fine grinding of synthetic rutile.

[3] Data are rounded to no more than three significant digits; may not add to total shown.

[4] All plants use the chloride process to manufacture TiO_2 pigment.

[5] Tronox Inc. idled its 110,000-t/yr plant in the fourth quarter of 2009, and did not operate the plant in 2010.

TABLE 5
COMPONENTS OF U.S. TITANIUM DIOXIDE PIGMENT SUPPLY AND DEMAND[1]

		2009		2010	
		Gross weight	TiO_2 content	Gross weight	TiO_2 content
Production[2]	metric tons	1,230,000	1,150,000 [e]	1,320,000	1,240,000
Shipments:[3]					
Quantity	do.	1,280,000	1,200,000 [e]	1,360,000	1,270,000
Value	thousands	\$2,830,000	XX	\$3,170,000	XX
Exports	metric tons	649,000	609,000 [e]	758,000	713,000 [e]
Imports for consumption	do.	175,000	165,000 [e]	204,000	192,000 [e]
Consumption, apparent[e, 4]	do.	757,000	710,000	767,000	719,000

[e] Estimated. do. Ditto. XX Not applicable.

[1] Data are rounded to no more than three significant digits.

[2] Excludes production of buff pigment.

[3] Includes interplant transfers.

[4] Production plus imports minus exports. Excludes stock changes.

Sources: U.S. Census Bureau and U.S. Geological Survey.

TABLE 6

ESTIMATED U.S. CONSUMPTION OF TITANIUM CONCENTRATE[1, 2]

(Metric tons)

	2009		2010	
	Gross weight	TiO_2 content	Gross weight	TiO_2 content
Pigment	1,620,000	NA	1,730,000	NA
Miscellaneous[3]	78,400	NA	90,000	NA
Total	1,700,000	1,360,000	1,820,000	1,460,000

NA Not available.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes a mixed product containing altered ilmenite, leucoxene, and rutile.

[3] Includes alloys, carbide, ceramics, chemicals, glass fibers, titanium metal, and welding-rod coatings and fluxes.

TABLE 7

U.S. CONSUMPTION OF TITANIUM IN STEEL AND OTHER ALLOYS[1, 2]

(Metric tons)

	2009	2010
Steel:		
Carbon steel	4,660	6,110
Stainless and heat-resisting steel	2,600	3,300
Other alloy steel[3]	524 r	649
Total steel	7,790 r	10,100
Cast irons	12	16
Superalloys	462	522
Alloys, other than above	994 r	1,020
Miscellaneous and unspecified	42 r	42
Grand total	9,300 r	11,700

r Revised.

[1] Includes ferrotitanium, scrap, sponge, and other titanium additives.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Includes high-strength low-alloy and tool steel.

TABLE 8
U.S. DISTRIBUTION OF TITANIUM PIGMENT SHIPMENTS, TITANIUM DIOXIDE CONTENT, BY INDUSTRY[1]

(Percent)

Industry	2009	2010 e
Paint, varnish, lacquer	59.2	57.1
Paper	10.1	9.7
Plastics and rubber	24.5	27.4
Other[2]	6.2	5.8
Total	100.0	100.0

eEstimated.

[1] Excludes exports.

[2] Includes agricultural, building materials, ceramics, coated fabrics and textiles, cosmetics, food, paper, and printing ink. Also includes shipments to distributors.

TABLE 9
YEAREND PRICES OF TITANIUM PRODUCTS

		2009	2010
Concentrate:			
Ilmenite, free on board (f.o.b.) Australian ports[1]	dollars per metric ton	60–85	65–85
Rutile, bagged, f.o.b. Australian ports[1]	do.	700–800	760–805
Rutile, bulk, f.o.b. Australian ports[1]	do.	525–540	530–550
Titaniferous slag, import, 80% to 95% TiO_2[2]	do.	401–439	367–433
Metal:			
Sponge import[2]	dollars per pound	4.50–7.07	3.50–6.24
Scrap, turnings, unproccessed[3]	do.	0.90–1.00	2.00–2.10
Ferrotitanium, 70% Ti[3]	do.	2.12–2.20	3.18–3.25
Mill products[4]	producer price index	197	203
Titanium dioxide pigment[4]	do.	164	194

do. Ditto.

[1] Source: Industrial Minerals.

[2] Landed duty-paid unit value based on U.S. imports for consumption.

[3] Source: Platts Metals Week.

[4] 1982=100. Source: U.S. Department of Labor, Bureau of Labor Statistics.

TABLE 10
U.S. EXPORTS OF TITANIUM BY CLASS[1]

Class	HTS[2]	2009		2010	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Metal:					
Scrap	8108.30.0000	4,200	$14,000	3,480	$19,200
Unwrought:					
Sponge	8108.20.0010	820	8,560	293	2,330
Ingot	8108.20.0030	776	19,800	467	9,530
Other	8108.20.0090	3,020	41,300	2,570	31,900
Wrought:					
Billet	8108.90.6010	2,010	75,200	2,240	77,600
Bloom, sheet bar, slab	8108.90.6020	913	26,900	1,240	35,500
Bar, rod, profile, wire	8108.90.6031	2,300	130,000	2,830	149,000
Other	8108.90.8000	7,240	476,000	8,450	531,000
Total		21,300	792,000	21,600	856,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	2,020	7,360	2,570	12,200
Ores and concentrates	2614.00.0000	14,800	8,230	18,900	11,800
Pigment:					
80% or more titanium dioxide pigment	3206.11.0000	617,000	1,230,000	717,000	1,570,000
Other titanium dioxide pigment	3206.19.0000	28,000	67,000	36,700	102,000
Unfinished titanium dioxide[3]	2823.00.0000	3,500	7,720	4,160	11,000
Total		649,000	1,310,000	758,000	1,690,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 11

U.S. IMPORTS FOR CONSUMPTION OF TITANIUM CONCENTRATE, BY COUNTRY[1]

		2009		2010	
Concentrate and country	HTS[2]	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Ilmenite:	2614.00.6020				
Australia		105,000	$10,200	98,200	$9,680
Mozambique		120,000	8,840	199,000	14,800
Ukraine		14,800	1,850	57,500	10,100
Other		10,200 [r]	917 [r]	22,300	3,070
Total		250,000	21,800	377,000	37,600
Titaniferous slag:	2620.99.5000				
Canada		109,000	44,600	150,000	64,700
South Africa		305,000	123,000	325,000	135,000
Other[3]		91	32	--	--
Total		414,000	168,000	475,000	200,000
Rutile, natural:	2614.00.6040				
Australia		122,000	70,700	83,500	55,000
Sierra Leone		10,800	5,970	29,800	17,300
South Africa		75,700	37,100	96,500	51,700
Other[3]		15,300 [r]	9,030 [r]	19,100	21,200
Total		224,000	123,000	229,000	145,000
Rutile, synthetic:	2614.00.3000				
Australia		48,000	14,000	109,000	45,500
Malaysia		4,790	2,920	4,460	2,620
Other[3]		2,810	848	9,170	4,310
Total		55,600	17,700	122,000	52,400
Titaniferous iron ore, Canada[4]	2614.00.6020	10,000	532	83,100	6,760

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] All or part of these data have been referred to the U.S. Census Bureau for verification.

[4] Includes materials consumed for purposes other than production of titanium commodities, principally heavy aggregate and steel-furnace flux. Titaniferous iron ore from Canada is classified as ilmenite under the HTS.

Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY[1]

Class and country	HTS[2]	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Waste and scrap:	8108.30.0000				
Canada		341	$563	682	$3,130
France		1,220	5,500	1,480	10,700
Germany		903	3,940	2,050	15,000
Israel		6	6	256	2,060
Italy		93	311	398	3,580
Japan		505	1,700	1,550	11,000
Korea, Republic of		100	683	416	2,820
Russia		68 [r]	615 [r]	243	1,860
Taiwan		133	516	692	3,870
United Kingdom		1,140	3,190	1,720	13,200
Other		264 [r]	613 [r]	1,230	8,260
Total		4,770	17,600	10,700	75,500
Unwrought:					
Sponge:	8108.20.0010				
Japan		5,870	81,600	9,790	110,000
Kazakhstan[e]		9,930	88,800	8,550	69,700
Other		806 [r]	7,600 [r]	2,120	17,000
Total		16,600	178,000	20,500	196,000
Ingot:	8108.20.0030				
China		--	--	48	631
Germany		364	10,300	156	2,640
Russia		155	2,830	12	154
Other		12	223	21	447
Total		531	13,300	237	3,880
Powder:	8108.20.0015				
China		17	385	96	1,830
Germany		2	468	6	1,180
Japan		4	1,070	6	1,380
Other		1 [r]	468 [r]	11	1,030
Total		24	2,390	119	5,420
Other:	8108.20.0091				
Canada		1	275	16	48
China		(4)	6	15	104
France		--	--	7	794
Germany		10	202	26	554
United Kingdom		4	572	21	2,230
Other		3 [r]	165 [r]	2	248
Total		18 [r]	1,220	88	3,980
Wrought products and castings:[3]	8108.90.3030, 8108.90.3060, 8108.90.6010, 8108.90.6020, 8108.90.6031, 8108.90.6045, 8108.90.6060, 8108.90.6075				
China		470	18,700	537	17,400
Japan		229	16,500	181	12,700
Russia		5,260	171,000	7,130	211,000
United Kingdom		309	32,800	140	15,600
Other		657 [r]	52,900 [r]	721	42,400
Total		6,930	292,000	8,710	299,000
Ferrotitanium and ferrosilicon titanium	7202.91.0000	2,540	6,750	2,740	11,500

[e] Estimated. [r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Includes bar, billet, bloom, castings, foil, pipe, plate, profile, rod, sheet, sheet bar, slab, strip, tube, wire, and other.

TABLE 12—Continued

U.S. IMPORTS FOR CONSUMPTION OF TITANIUM METAL, BY CLASS AND COUNTRY[1]

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[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 13

U.S. IMPORTS FOR CONSUMPTION OF TITANIUM PIGMENT, BY COUNTRY[1]

Country	HTS[2]	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
80% or more titanium dioxide pigment:	3206.11.0000				
Australia		2,660	$4,400	2,000	$3,930
Canada		59,600	130,000	83,400	183,000
China		9,910	15,600	8,120	15,800
Finland		8,290	19,100	7,970	16,000
France		3,150	5,980	4,200	8,990
Germany		6,970	14,900	5,720	13,300
Italy		4,870	9,120	2,890	6,170
Japan		3,300	12,800	4,350	18,600
Netherlands		3,620	6,880	4,730	9,790
South Africa		10,300	21,300	2	4
Ukraine		6,150	9,560	9,890	15,900
Other		11,400 [r]	21,300 [r]	11,700	22,900
Total		130,000	271,000	145,000	314,000
Other titanium dioxide:	3206.19.0000				
Canada		8,160	20,700	7,230	18,600
China		766	2,880	1,550	4,510
Germany		2,500	7,800	1,440	5,230
Japan		509	5,450	836	7,910
Other		1,020 [r]	7,020 [r]	1,060	8,870
Total		13,000	43,900	12,100	45,100
Unfinished titanium dioxide:[3]	2823.00.0000				
China		9,880	14,200	22,400	41,300
Czech Republic		1,920	3,480	2,400	4,610
Finland		1,800	4,450	2,960	6,960
France		4,350	14,500	4,910	16,400
Germany		3,570	7,750	4,920	10,700
Japan		5,240	16,900	1,110	7,020
Korea, Republic of		2,980	3,890	4,450	7,600
Other		2,180 [r]	4,940 [r]	4,030	8,810
Total		31,900	70,100	47,200	103,000
Grand total		175,000	385,000	204,000	462,000

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Unmixed and not surface treated.

Source: U.S. Census Bureau.

TABLE 14
TITANIUM: WORLD PRODUCTION OF MINERAL CONCENTRATES, BY COUNTRY[1, 2]

(Metric tons)

Concentrate type and country	2006	2007	2008	2009	2010
Ilmenite and leucoxene:[3, 4]					
Australia	2,508,000	2,503,000	2,230,000 [r]	1,611,000 [r]	1,651,000
Brazil[5]	94,909 [r]	100,364 [r]	175,076 [r]	71,122 [r]	75,000
China[e]	1,000,000	1,100,000	1,100,000	900,000 [r]	1,000,000
India[e]	690,000	700,000	610,000 [r]	700,000 [r]	900,000
Kazakhstan[e]	25,000	25,000	25,000	25,000	25,000
Malaysia	45,649	60,250	36,779	15,983 [r]	19,064 [e]
Mozambique	--	140,515	328,875	471,524 [r]	678,000
Norway[e]	850,000	882,000	915,000 [r]	671,000 [r]	670,000
Sierra Leone	13,819	15,750	17,528	15,164 [r]	18,206 [e]
Sri Lanka	57,033 [r]	70,728 [r]	22,159 [r]	122,424 [r]	52,637
Ukraine	470,000	500,000	520,000 [r]	500,000 [e]	500,000 [e]
United States[e, 6]	500,000	400,000	300,000	300,000	400,000
Vietnam[7]	604,700 [r]	643,400 [r]	692,700 [r]	686,800 [r]	881,000 [e]
Total[8]	6,860,000 [r]	7,140,000 [r]	6,970,000 [r]	6,090,000 [r]	6,870,000
Rutile:[4]					
Australia	232,000	312,000	325,000	281,000 [r]	380,000
Brazil[5]	2,100	3,000	2,431	2,881	2,900
India[e]	21,000	21,000	21,000	21,000	25,000
Madagascar	--	--	--	3,200 [r, e]	5,700 [e]
Malaysia	1,450	1,450	1,834	1,502	7,567
Mozambique	--	8,782	6,552	1,697	4,656
Sierra Leone	73,802	82,527	78,908	63,864	68,198
South Africa[e]	123,000	114,000	127,000	134,000	153,000
Sri Lanka	2,280 [r]	4,607 [r]	11,335 [r]	2,276 [r]	2,568
Ukraine[e]	60,000	60,000	60,000	60,000	60,000
United States	(9)	(9)	(9)	(9)	(9)
Total	516,000 [r]	607,000 [r]	634,000 [r]	571,000 [r]	710,000
Titaniferous slag:[e, 10]					
Canada	930,000	960,000	1,000,000	765,000	1,090,000
South Africa	1,230,000	1,270,000	1,230,000	1,230,000	1,120,000
Total	2,160,000	2,230,000	2,230,000	2,000,000	2,210,000

[e] Estimated. [r] Revised. -- Zero.

[1] Totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 11, 2011.

[3] Ilmenite is also produced in Canada, Madagascar, and South Africa, but this output is not included here because most of it is duplicative of output reported under "Titaniferous slag," and the rest is used for purposes other than production of titanium commodities, principally steel furnace flux and heavy aggregate.

[4] Small amounts of titanium minerals were reportedly produced in various countries; information, however, is inadequate to make reliable estimates of output levels.

[5] Excludes production of unbeneficiated anatase ore.

[6] Includes rutile to avoid disclosing company proprietary data. Rounded to one significant digit.

[7] Estimate based on import statistics from trading partners (primarily China and Japan).

[8] Includes U.S. production, rounded to one significant digit, of ilmenite, leucoxene, and rutile to avoid disclosing company proprietary data.

[9] Included with ilmenite to avoid disclosing company proprietary data.

[10] Slag is also produced in China, Norway, Kazakhstan, Russia, and Vietnam, but this output is not included under "Titaniferous slag" to avoid duplicative reporting.

TUNGSTEN

By Kim B. Shedd

Domestic survey data and tables and the world production table were prepared by Lisa D. Miller, international data oordinator.

In 2010, one U.S. tungsten operation shipped ore oncentrates. Most of the U.S. supply of tungsten raw materials omprised imports, scrap, and sales from the National Defense tockpile (NDS). China continued to be the world's leading roducer of tungsten concentrates and the leading supplier f tungsten imports to the United States. U.S. apparent onsumption increased significantly in 2010, as compared with hat of 2009. Salient U.S. tungsten statistics and world tungsten oncentrate production for 2010 and the previous 4 years are sted in table 1.

Most data in this report have been rounded to three significant igits. Totals and percentages were calculated from unrounded umbers. Unless otherwise specified, all statistics in this report re in metric tons of contained tungsten. Tungsten prices and nany tungsten statistics from other sources are quoted in units f tungsten trioxide (WO_3). The short ton unit, which is used in he United States, is 1% of a short ton (20 pounds), and WO_3 is 9.3% tungsten by weight. A short ton unit of WO_3, therefore, quals 20 pounds of WO_3 and contains 7.19 kilograms (kg) 15.86 pounds) of tungsten. The metric ton unit, which is used in nost other countries, is 1% of a metric ton (10 kg). A metric ton nit of WO_3, therefore, equals 10 kg of WO_3 and contains 7.93 g (17.48 pounds) of tungsten.

Tungsten is a whitish-gray metal with many unique properties nd a wide variety of commercial, industrial, and military pplications. The leading use is as tungsten carbide in cemented arbides, which are wear-resistant materials used by the onstruction, metalworking, mining, and oil and gas drilling ndustries. Pure or doped tungsten metal contacts, electrodes, nd wires are used in electrical, electronic, heating, lighting, nd welding applications. Tungsten is also used to make lloys and composites to substitute for lead in ammunition nd other products; heavy-metal alloys for armaments, heat inks, radiation shielding, and weights and counterweights; uperalloys for turbine engine parts; tool steels; and wear-esistant alloy parts and coatings. Tungsten chemicals are sed to make catalysts, corrosion-resistant coatings, dyes and pigments, fire-resistant compounds, lubricants, phosphors, and semiconductors.

Legislation and Government Programs

The Defense Logistics Agency (DLA), U.S. Department of Defense, changed the name of the Defense National Stockpile Center to DLA Strategic Materials. DLA had two sales formats for NDS tungsten materials—negotiated sales and a strategic supply alliance (SSA). Under the SSA format, prequalified purchasers could submit bids for tungsten ores and concentrates via the DLA Web site at any time, 24 hours per day and 7 days per week. During fiscal year 2010 (October 1, 2009, through September 30, 2010), 2,670 metric tons (t) of contained tungsten was sold. During the calendar year, 2,060 t of tungsten was sold. The quantities of uncommitted tungsten materials remaining in the stockpile at the end of the calendar year are listed in tables 1 and 2 (U.S. Department of Defense, 2011, p. 8).

The Annual Materials Plan (AMP) for fiscal year 2010, which represented the maximum quantities of tungsten materials that could be sold, is listed in table 2. The proposed AMP for fiscal year 2011 (October 1, 2010, through September 30, 2011), was to remain unchanged for tungsten. Sales of tungsten materials were curtailed in order to hold a goal quantity equivalent to 1 year's AMP (U.S. Department of Defense, 2011, p. 2, 6–7).

The Dodd-Frank Wall Street Reform and Consumer Protection Act (Public Law 111–203) was signed into law on July 21. Section 1502 of the law required annual reporting by companies that file reports with the U.S. Securities and Exchange Commission for whom conflict minerals were necessary to the functionality or manufacture of their products. Conflict minerals were defined as columbite-tantalite (coltan), cassiterite, gold, wolframite, or their derivatives, or any other mineral or its derivatives determined by the Secretary of State to be financing conflict in Congo (Kinshasa) or an adjoining country. Wolframite is one of two principal minerals mined for tungsten. Tungsten mine production from Congo (Kinshasa) and adjoining countries is typically less than 4% of world production (table 15).

Production

Domestic production statistics for tungsten are based on data collected by the U.S. Geological Survey (USGS) by means of two separate voluntary surveys. Statistics that result from these surveys are listed in tables 1 and 3. The annual "Tungsten Ore and Concentrate Survey" covered the production, purchase, disposition, and stocks of tungsten ores and concentrates. In 2010, Curtis Tungsten, Inc. (Upland, CA) produced and shipped scheelite concentrates from the Andrew Mine northeast of Los Angeles, CA.

EMC Metals Corp. (Vancouver, British Columbia, Canada) appointed an agent for the sale of its Springer complex in Pershing County, NV. The complex comprised an underground scheelite mine, a mill, and a processing plant designed to produce either ammonium paratungstate (APT) or calcium tungstate (also known as synthetic scheelite). The mine and mill had a rated output of 146,000 metric ton units per year [1,160 metric tons per year (t/yr) of contained tungsten]. Although on care-and-maintenance status since 1982, investments have been made to the facilities in recent years, and work to make the primary milling and flotation circuits fully operational was nearly complete. By yearend, EMC had expanded its options for Springer to include restarting operations, establishing a joint venture, or selling the assets (EMC Metals Corp., 2011a, p. 7; b, p. 7, 14).

The USGS monthly "Tungsten Concentrate and Tungsten Products Survey" canvassed companies that produced tungsten carbide powder, tungsten chemicals, and (or) tungsten metal powder from APT, tungsten-bearing scrap, and tungsten concentrate. U.S. processors of tungsten materials operating in 2010 are listed in table 4.

In 2010, U.S. processors consumed more tungsten concentrates, APT, and scrap than they did in 2009. Domestic production of APT was higher than that of 2009. Total net production of tungsten metal powder and tungsten carbide powder increased by 57% in 2010 compared with that of 2009 (table 3).

Global Tungsten & Powders Corp. (GTP) announced that it planned to invest more than $10 million in its Towanda, PA, plant. The investment reportedly would include new technology for tungsten metal powder production and would increase the plant's tungsten metal powder production capacity (Loewenstein, 2010).

Consumption

U.S. apparent consumption of all tungsten materials, as calculated from net imports, secondary production, and changes in Government and industry stock levels, was 15,600 t in 2010, 34% higher than the 2009 apparent consumption of 11,600 t. Primary U.S. production was not included in the calculation to avoid disclosing company proprietary data. The increase in apparent consumption in 2010 was the result of significantly higher net imports, scrap consumption, and NDS shipments compared with those of 2009.

Statistics on consumption of tungsten in end-use applications by U.S. metal consumers were developed from the voluntary "Consolidated Consumers Survey." For this survey, more than 50 tungsten consumers were canvassed on a monthly or annual basis. Reported consumption and stock data in tables 1 and 5 include estimates to account for nonrespondents.

Total U.S. reported consumption of tungsten materials to make end-use products in 2010 was 46% higher than that of 2009. With the exception of steelmakers and producers of other alloys, tungsten consumption by all industries (producers of cemented carbides, chemical products, mill products, and superalloys) was higher than that of 2009. Compared with consumption in 2009, U.S. end users consumed more tungsten chemicals, tungsten carbide powder, tungsten metal powder, and tungsten scrap, but less ferrotungsten.

Weekly reports of the number of operating drilling rigs give an indication of the demand for tungsten carbide in the form of cemented carbide components used by industry to explore for or produce oil and natural gas. The number of rigs operating each week in the United States trended upward during the year. In 2010, the average of weekly operating rigs was 1,546, 42% higher than the average of 1,089 operating rigs in 2009 (Baker Hughes Inc., undated).

In 2010, total consumption of tungsten scrap by U.S. processors and consumers was 5,880 t of contained tungsten, which was 66% more than the 3,550 t consumed in 2009.

Prices

APT is the most widely traded primary tungsten material, and as a result, its price has become a reference price for such upstream materials as tungsten ore concentrates and such downstream materials as tungsten metal powder and tungsten carbide powder. Annual average APT prices increased from those of 2009 (table 1). The U.S. APT price reported by Platts Metals Week increased three times during the year and ranged from $154 to $220 per short ton unit ($170 to $243 per metric ton unit). U.S. APT prices reported by Metal Bulletin were fairly stable during the first 7 months of the year, decreased slightly in late July, increased four times between mid-August and late October, and then were stable throughout the remainder of the year. They ranged between $160 and $243 per short ton unit ($176 to $268 per metric ton unit).

The semiweekly tungsten ore price reported by Metal Bulletin has remained unchanged since late 2008 (table 1). The U.S. spot tungsten ore concentrate price reported by Platts Metals Week increased twice during the year and ranged from $131 to $175 per short ton unit ($144 to $193 per metric ton unit). The annual average of Platts' tungsten ore concentrate prices increased by 21% from that of 2009. Platts' annual average ferrotungsten price increased by 22% to $34.30 per kilogram of contained tungsten in 2010 from $28.08 per kilogram of contained tungsten in 2009. In 2010, the ferrotungsten price ranged between $25.50 and $52 per kilogram.

Foreign Trade

The tungsten content of U.S. exports was 4,620 t, 67% more than the 2,770 t exported in 2009. In 2010, the quantity of tungsten in every export category except for ferrotungsten and waste and scrap was higher than that of 2009 (tables 6–10).

The tungsten content of U.S. imports was 12,400 t, 24% more than the 10,000 t imported in 2009. China, which continued to be the leading supplier of imported tungsten to the United States, provided 49% of all tungsten imports in 2010. In 2010, the tungsten content of imports from China increased by 33% to 6,080 t from 4,580 t in 2009. The distribution of materials imported from China was as follows: APT, 40%; tungsten oxide, 18%; tungsten carbide powder, 16%; wrought tungsten, 9%; ferrotungsten and unwrought tungsten, 5% each; tungsten metal powders, 4%; and tungsten waste and scrap, other tungstates, and other tungsten compounds, minor amounts. Other significant suppliers of tungsten materials to the United States were as follows: Bolivia, 8%; Germany and Portugal, 5% each; and Israel, Peru, and the Republic of Korea, 4% each.

The tungsten contained in U.S. imports of ores and concentrates was 24% lower than that of 2009 (table 11). In 2010, the leading suppliers of U.S. imports of tungsten ores and concentrates were Bolivia (34%), Portugal (23%), Peru (19%), and Spain (8%).

U.S. imports of APT were slightly lower than those of 2009 (table 12). China continued to be the dominant supplier, providing 96% of U.S. APT imports. Imports of other tungsten materials are presented in tables 13–14.

In 2010, U.S. net import reliance for tungsten as a percentage of apparent consumption was 63%. Net import reliance as a percentage of apparent consumption is used to measure the adequacy of current domestic production to meet U.S. demand. Net import reliance was defined as imports minus exports plus adjustments for Government and industry stock changes.

Releases from stocks, including shipments from the NDS, were counted as part of import reliance, regardless of whether they were imported or produced in the United States. Because there was only limited U.S. mine production in 2010, about 63% of U.S. tungsten supply was from imports and stock releases, and 37% was from scrap materials generated in the United States.

World Review

Estimated world tungsten mine production increased significantly from that of 2009, primarily because of an increase in production from China (table 15). In addition to mine production and tungsten recovered from scrap, tungsten materials from the NDS contributed to supply in 2010.

The European Commission reported the results of a study of 41 economically important minerals and metals. Tungsten was one of 14 raw materials identified as critical for European Union supply within a period of 10 years, based on their high economic importance and high risk of supply shortage relative to other materials in the study. For tungsten, the high risk of supply shortage was because a large share of worldwide production comes from China. Tungsten's criticality was increased by economic, performance, and environmental issues of potential substitutes (European Commission, 2010, p. 5–6, 23, 38).

Australia.—Tasmania Mines Ltd. (Sydney) produced a small amount of scheelite concentrate from its Kara open pit magnetite mine south of Burnie in Tasmania.

Hazelwood Resources Ltd. (Perth) studied the feasibility of developing the Big Hill scheelite deposit within its Cookes Creek project area in northwestern Western Australia. A prefeasibility study indicated that the mine could produce up to 200,000 metric ton units per year of concentrate (1,600 t/yr of tungsten) during a 12-year period beginning in 2012. The ore would be preconcentrated using ore-sorting methods, milled, and then processed by conventional gravity separation methods. Hazelwood planned to use the concentrate from Big Hill as feedstock for the Asia Tungsten Products Co. Ltd. ferrotungsten plant, which was under construction in Vietnam (Hazelwood Resources Ltd., 2010, p. 1, 5, 16).

Icon Resources Ltd. (Sydney) decided to focus solely on tungsten and planned a staged development of its Mt. Carbine tungsten mine west of Port Douglas in northern Queensland. The first stage of production would be from retreating tailings generated during past mining operations, the second stage would entail crushing, sorting, and milling low-grade stockpiled ore, and the final stage would be mining from open pit and underground operations. The company planned to begin construction of a tailings processing plant in 2011 (Icon Resources Ltd., 2011).

Hunan Nonferrous Metals Corp. Ltd. (Changsha, China) withdrew from the Dolphin Joint Venture with King Island Scheelite Ltd. (KIS, Sydney), which had been established to redevelop the former King Island Scheelite Mine at Grassy, King Island, northwest of Tasmania. At yearend, KIS was considering a base case for the Dolphin project that included underground mining from stopes and pillars left from previous mining operations and milling 300,000 t/yr of ore, which would be processed by flotation to produce more than 2,600 t/yr of tungsten in concentrate. The company was investigating strategies to reduce project risk and increase project value before seeking funding to redevelop the mine (King Island Scheelite Ltd., 2011).

Planet Metals Ltd. (Brisbane) maintained its Wolfram Camp tungsten-molybdenum project west of Cairns, Queensland, on care-and-maintenance status. During 2010, the company made two unsuccessful attempts to sell the project, first to Tropical Metals Pty. Ltd. (Brisbane) and later to Hazelwood Resources (Planet Metals Ltd., 2011 a, b).

Austria.—Wolfram Bergbau und Hütten AG (owned by Sandvik AB, Sandviken, Sweden) operated the Mittersill scheelite mine and mill in the State of Salzburg, the Bergla tungsten processing plant, and a tungsten recycling unit near St. Martin in the State of Steiermark.

Brazil.—Largo Resources Ltd. (Toronto, Ontario, Canada) completed a preliminary economic assessment on the Currais Novos project, which would reprocess tailings generated by past production from the Barra Verde and Boca de Laje tungsten-molybdenum mines west-southwest of Natal, Rio Grande do Norte State. Largo was considering a 4-year operation, which would produce scheelite concentrate containing 62,000 metric ton units per year (approximately 500 t/yr of tungsten). The company planned to build the plant and begin producing concentrate in 2011 and had a preliminary agreement to sell the concentrate to GTP (Salari and others, 2011, p. 79–83).

Canada.—In October, North American Tungsten Corp. Ltd. (Vancouver) restarted operations at its Cantung Mine in the Northwest Territories. The mine had been placed on care-and-maintenance status in October 2009 in response to weak demand, low tungsten prices, and increasing inventories of tungsten concentrates and primary materials. Concentrate production during the restart was significantly below target levels, owing to a shortfall in the quantity of ore mined resulting from development delays and a shortage of underground equipment. In 2010, the company produced 420 t (53,000 metric ton units) of tungsten in scheelite concentrates, of which 334 t (42,100 metric ton units) was in gravity concentrate and 86 t (10,800 metric ton units) was in flotation concentrates. North American Tungsten continued to evaluate the development of its Mactung scheelite deposit in the Yukon. The company was considering an open pit mine in addition to the underground mine proposed in a 2009 feasibility study (North American Tungsten Corp. Ltd., 2011, p. 3–4).

Geodex Minerals Ltd. (Vancouver, British Columbia) formed a joint venture with Northcliff Exploration Ltd. (Vancouver, British Columbia) to develop the Sisson tungsten-molybdenum project in New Brunswick. Northcliff would acquire a 70% interest in the project by funding a feasibility study and beginning mine construction. A 2009 scoping study on the project proposed the development of an open pit mine and beneficiation plant to produce concentrates containing 470,000 metric ton units per year (approximately 3,700 t/yr of tungsten) and 1,600 t/yr of molybdenum for a period of 20 years (Geodex Minerals Ltd., 2011, p. 3, 15, 18).

H.C. Starck GmbH (Goslar, Germany) received an Advanced Manufacturing Investment Strategy loan from the Ontario

Provincial government to expand the company's tungsten plant in Sarnia, Ontario. The company had approval from the Ontario Ministry of the Environment for a manufacturing facility with a capacity to produce 4,500 t/yr of metal powder, including tungsten metal, tungsten carbide, and cast tungsten carbide powders, but suspended the expansion in 2009 owing to global economic conditions. H.C. Starck planned to transfer its expertise and manufacturing of high-tech powders for oil and gas drilling bits to Sarnia and complete the expansion project in 2010 (Ontario Ministry of the Environment, 2009; H.C. Starck GmbH, 2010).

China.—China's Government had a program to conserve its tungsten resources and to try to stabilize tungsten prices. In the mining sector, the Government regulated the production of tungsten concentrates by forbidding foreign investment in tungsten exploration and mining; closing mines that did not meet certain energy, environmental, production, and safety standards; imposing a resource tax on tungsten ores; not issuing new exploration and mining licenses; and setting production quotas. For 2010, the tungsten concentrate production quota was increased by 17% to 80,000 t (65% WO_3). Concentrates recovered from tailings were 17% of the quota, and combined production from mining and tailings recycling was to be distributed by province or autonomous region as follows: Jiangxi (44%), Hunan (25%), Henan (6%), Yunnan (5%), Guangdong and Guangxi (4% each), Fujian and Inner Mongolia (3% each), Anhui and Gansu (2% each), Heilongjiang (1%), Zhejiang (0.4%), Hubei and Xinjiang (0.3% each), and Hainan, Shaanxi, and Qinghai (0.2% each). Local entities, such as the Ganzhou City Government (Jiangxi Province) and the Ganzhou Tungsten Industry Association (GTIA), also regulated the production and marketing of tungsten, including GTIA's monthly recommended prices for tungsten concentrates, APT, and metal powder. In 2010, the Government reportedly considered tying the resource tax on tungsten ores to the tungsten price (Huang, 2008; Ganzhou Government Online, 2009; Huang, 2009; Asian Metal, 2010; China Metal Market—Precious & Minor Metals Monthly, 2010a, b; Fang, 2011, p. 4, 44, 48; Fang Jiyun, deputy general manager, Tungsten Department, China Minmetals Non-ferrous Metals Co., Ltd., written commun., October 9, 2011).

In the processing sector, the Government encouraged the recovery of tungsten from low-grade ores, mixed scheelite-wolframite concentrates, and scrap; banned tolling of tungsten concentrate; limited foreign investment in processing plants; and maintained requirements to limit the building or expansion of plants. These requirements included minimum capacities, the ability to secure reliable supplies of raw materials, the use of the company's own funds for 50% or more of the investment, and meeting environmental, energy, production, and safety standards (China Metal Market—Precious & Minor Metals Monthly, 2006; Fu, 2007; Zhang, 2007; Huang, 2008; Huang, 2009).

With respect to trade, the Government regulated tungsten exports by restricting the volumes and types of materials and products that could be sent out of the country, limiting the number of producers and traders authorized to export tungsten materials and products, and adjusting the export tax system. Before 2010, two departments in the Ministry of Commerce issued export licenses—one for foreign trade and the other for foreign investment. The quota for foreign investment was typically 1,700 t/yr to 1,900 t/yr, and was not included in the quotas reported by trade journals prior to 2010. Beginning in 2010, all licenses were issued by one department and included the amounts for foreign investment. The 2010 export quota for tungsten materials was 16,000 t of contained tungsten, down from 16,300 t in 2009. To qualify for an export license, companies were required to have minimum production capacities and recycling rates. In mid-July, the Chinese Government canceled export tax rebates for certain materials, including tungsten articles (Ryan's Notes, 2007, 2010a; Huang, 2009; Fang, 2011, p. 24, 44, 46).

In spite of its position as the world's leading miner of tungsten, China has imported tungsten concentrates in recent years. In 2010, China imported 3,160 t of tungsten in concentrates, 33% less than it imported in 2009. The decrease in imports was attributed to a buildup of stocks during 2009, which were drawn down during 2010. In addition, China planned to add tungsten to its strategic stockpile (People's Daily Online, 2010; Ryan's Notes, 2010b; Fang, 2011, p. 31).

Congo (Kinshasa).—The President of Congo (Kinshasa) temporarily banned all artisanal mining in the eastern provinces of Maniema, Nord-Kivu, and Sud-Kivu. The ban, which was in effect for about 1 month, was intended to restrict illegal mining and trade in minerals that provided funding to rebel groups (Metal-Pages, 2010a).

Japan.—The Ministry of Economy, Trade and Industry (METI) planned to reduce Japan's dependence on China for its supply of tungsten raw materials. METI's strategy comprised providing assistance to develop new mine production in other countries, increasing recycling rates, promoting research to reduce consumption by increasing the life of tungsten products or developing substitutes, and making improvements to the stockpiling program (Japan Oil, Gas and Metals National Corp., 2011, p. 1–2).

Korea, Republic of.—The South Korean Government reportedly planned to invest in developing the country's rare-metals production industry and to secure a strategic stockpile of various metals, including tungsten, by 2016. The program was to include assistance with exploration, partnerships with countries having metal resources, and the development of metal processing technologies (Young-aah, 2010).

Woulfe Mining Corp. (Vancouver, British Columbia, Canada) commissioned Wardrop Engineering Inc. to prepare a feasibility study on reopening the Sangdong tungsten-molybdenum mine approximately 170 kilometers southeast of Seoul in Gangwon Province. The Sangdong Mine operated for more than 50 years before its closure in 1992 and had been a significant producer of tungsten. The feasibility study was to evaluate a 1.25-million-metric-ton-per-year (Mt/yr) underground mining operation, a beneficiation plant to produce tungsten and molybdenum concentrates, and an onsite processing plant with the capacity to produce 400,000 metric ton units per year of APT (approximately 3,200 t/yr of contained tungsten). The study would also consider the potential for doubling the mine capacity to 2.5 Mt/yr of ore. Late in the year, Woulfe entered into a heads of agreement with Korea Zinc Co. Ltd. to help finance the project, which it hoped to have in commercial production by 2013 (Woulfe Mining Corp., 2011, p. 2–5).

Peru.—In the Ancash region, Malaga Inc. (Montreal, Quebec, Canada) produced tungsten concentrate from the Pasto Bueno mine and mill; the concentrate was sold to U.S. tungsten processor GTP under an offtake agreement. During the year, Malaga doubled its mill capacity to 500 metric tons per day (t/d) of ore, which was equivalent to concentrate production of more than 100,000 metric ton units per year (approximately 800 t/yr of tungsten). The company began an extensive exploration and development program to increase mine capacity to 500 t/d, and planned an additional increase in mill capacity to 600 t/d by yearend 2011 (Malaga Inc., 2011a, p. 9–10; b, p. 9, 13).

Portugal.—Sojitz Beralt Tin and Wolfram (Portugal) S.A. (Barroca Grande) produced wolframite concentrates from the Panasqueira Mine and beneficiation plant in central Portugal.

Russia.—In 2010, Russian production of tungsten concentrates and intermediates (APT, tungsten anhydride, and tungsten oxide) and consumption of scrap and primary tungsten products (chemicals, ferrotungsten, and metal powders) increased from the low levels seen in 2009. Five companies mined tungsten and produced concentrates. The companies, with the locations of their operations and listed in order of their share of 2010 production, were as follows: JSC A&IR Mining, which produced concentrates from ores mined by Primorsky GOK in Primorskiy Kray; Russkaya Gornorudnaya Kompaniya (RGRK, the Russian Ore Mining Company) managed JSC Novoorlovsky GOK in Zabaykal'sk Kray; prospectors' cooperative Artel Quartz Ltd. (Kvarz) in Zabaykal'sk Kray; Wolfram Company CJSC, which owned CJSC Buryat Wolfram in Zakamensk, Buryatiya Republic; and KGUP Primteploenergo, which won the exploration and mining license for the Lermontov Mine in Primorskiy Kray. In addition, OOO Sibinvest (Tomsk) reportedly planned to begin mining and processing ores from the Kalgutinskiy wolframite-molybdenite deposit in the Altay Republic (Metal-Pages, 2010b; Gorbachev, 2011, p. 6–8, 18).

Wolfram Company (Moscow) Hydrometallurg plant at Nalchik, Kabardino-Balkariya Republic, and Kirovgradskiy Zavod Tverdykh Splavov OAO's Kirovgrad Hard Alloys plant in Sverdlovsk Oblast produced APT, tungsten anhydride, and tungsten oxide. Russian production of these materials increased from the low levels produced in 2009. In addition to concentrates, Russian supply included about 450 t of tungsten scrap in 2010 (Gorbachev, 2011, p. 9, 11–16).

Wolfram also completed the first phase of a refractory metals plant in Unecha, Bryansk Oblast, which was expected to produce tungsten metal powders as its main product. The company planned to gain full control of the Tyrnyauz tungsten-molybdenum mining complex by purchasing the share held by the Kabardino-Balkariya Republic (Wolfram Company CJSC, undated a, b).

Rwanda.—In recent years, wolframite has been mined by privately owned companies, cooperatives, unlicensed artisanal miners, and the Government of Rwanda, listed in order of share of production volume (Transafrika Resources Ltd., 2010).

Spain.—Heemskirk Consolidated Ltd. (Melbourne, Australia) completed a project to increase mill throughput and tungsten recovery at the Los Santos tungsten mine in Salamanca Province. The company aimed to increase its annual output to between 90,000 metric ton units and 100,000 metric ton units (between 714 t/yr of tungsten and 793 t/yr of tungsten). All of the scheelite concentrate produced through 2013 was committed to GTP under a 6-year offtake agreement. In December, Heemskirk announced that it had signed a letter of intent to sell the Los Santos operation to New York-based private equity firm Almonty Partners LLC (Heemskirk Consolidated Ltd., 2010a, p. 4–5, 58; b, p. 14).

Ormonde Mining plc (Dublin, Ireland) studied the feasibility of developing its Barruecopardo tungsten project in Salamanca Province and began the permitting process for a mining operation. Barruecopardo was the leading tungsten mine in Spain until its closure in the early 1980s. Ormonde was considering an open pit mine and beneficiation plant that would use gravity and flotation methods to produce scheelite concentrates containing 130,000 metric ton units per year (approximately 1,000 t/yr of tungsten). After the first 10 years of operation, mining would be moved underground. Ormonde hoped to begin production from Barruecopardo in late 2012 (Ormonde Mining plc, 2011, p. 4–6).

Sweden.—Sandvik AB (Sandviken), a global tool, material, and machinery manufacturer, worked to increase the use of secondary raw materials (scrap) to make its products. In 2010, nearly 60% of the tungsten used by the Sandvik Tooling business area, excluding Wolfram Bergbau, was derived from recycling cemented carbide products. The Sandvik Mining and Construction business area collected about 10% of its annual production of rock-drilling tools for recycling, which generated 80 t of tungsten-bearing powder (Sandvik AB, 2011, p. 103).

United Kingdom.—Wolf Minerals Ltd. (Subiaco, Australia) continued to study the feasibility of redeveloping the Hemerdon tungsten and tin mine northeast of Plymouth. The open pit mine and milling operation was expected to produce approximately 360,000 metric ton units per year (2,850 t/yr of tungsten) in wolframite concentrate and 500 t/yr of tin in concentrate for 12 years beginning in 2013. In early 2011, the Devon County Council and United Kingdom Secretary of State granted updated planning permission for mining at the project, and Wolf Minerals entered into a 6-year formal agreement with Traxys Europe S.A. to market offtake agreements for and deliver all of the tungsten concentrates produced (Wolf Minerals Ltd., 2011a, b).

Vietnam.—Vietnam Youngsun Tungsten Industry Co., Ltd. produced ferrotungsten in Halong City, Quang Ninh Province. Most of the production was from scheelite and wolframite ores purchased from Thienke Mine in Tuyen Quang Province and Philieng Mine in Lam Dong Province. The ferrotungsten was produced for export to Europe, Japan, the Republic of Korea, and the United States (Vietnam Youngsun Tungsten Industry Co., Ltd., 2009a, b).

Hazelwood Resources acquired a 60% interest in Asia Tungsten Products and established a joint venture for the construction and operation of a ferrotungsten plant in the Vihn Bao district near the port of Haiphong. The plant would produce ferrotungsten containing 80% tungsten and was to be built in two stages. Stage 1, with the capacity to produce 2,400 t/yr of tungsten contained in ferrotungsten, was under construction and would be in production in 2011. Stage II, which would require additional permitting and approvals, would double the capacity. Feedstock for the plant initially would be purchased, and then later supplemented with concentrates from Hazelwood's Big Hill Mine in Australia. The plant was also licensed to produce sodium tungstate (Hazelwood Resources Ltd., 2010, p. 1, 5, 11).

Masan Group Corp. (Ho Chi Minh City) acquired control of Nui Phao Mining Joint Venture Company Ltd. from Tiberon Minerals Pte. Ltd., a company owned by Dragon Capital Group. By early 2011, Masan had 100% ownership of the Nui Phao project in Thai Nguyen Province. The project comprised an open pit mine and mill to produce tungsten, copper, and fluorspar concentrates and bismuth cement for more than 16 years. Masan forecast tungsten output during the first 5 years of full production to average 5,300 t/yr of contained tungsten and was considering the inclusion of a plant to produce APT. The company obtained an updated investment certificate and new mining license, completed more than 80% of the compensation and resettlement for land required for construction, and completed the first round of financing for the project. The company planned to begin production in 2013 (Heaton, 2011, p. 7–8, 33–35; Masan Group Corp., 2011).

Outlook

World tungsten supply will continue to be dominated by Chinese production and exports. The Chinese tungsten concentrate production quota for 2011 was increased by 9% to 87,000 t (65% WO_3). Export licenses for 2011 were limited to 15,700 t of all tungsten products, a decrease of 2% from the quota of 16,000 t in 2010 (Fang, 2011, p. 4, 24).

Tungsten use is strongly influenced by general economic conditions. Future consumption of tungsten in cemented carbides, which is the leading end-use sector, will depend on the performance of the following industries: automotive and aircraft production; construction; electronics manufacturing, where cemented carbide microdrills are used on circuit boards; general manufacturing; large equipment manufacturing; mining; and oil and gas drilling. Tungsten use is also influenced by Government spending for defense applications. During the first half of 2011, tight supplies of tungsten concentrates in China, combined with strong demand, resulted in significant increases in the prices of tungsten concentrates and downstream products such as ferrotungsten and APT (Ryan's Notes, 2011).

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TABLE 1

SALIENT TUNGSTEN STATISTICS[1]

(Metric tons of tungsten content and dollars per metric ton unit)

	2006	2007	2008	2009	2010
United States:					
Concentrates:					
Production	--	W	W	W	W
Consumption	W	W	W	W	4,840
Exports	130	109	496	38	276
Imports for consumption	2,290	3,880	3,990	3,590	2,740
Stocks, December 31:					
Consumer	W	W	W	W	W
U.S. Government[2]	22,900	21,200	19,700	19,000	17,000
Price:					
U.S. spot quotation[3]	200	189	184	151	183
European[4]	166	165	164	150	150
Ammonium paratungstate:					
Production	W	W	W	W	W
Consumption[5]	11,300	12,000	9,700	6,860	10,300
Stocks, December 31, producer and consumer	W	68	W	100	62
Price:					
U.S. free market[6]	293	284	278	204	214
U.S. market[3]	273	262	260	178	186
European free market[6]	261	248	249	203	244
Primary products:					
Net production[7]	8,050	8,360	8,950	5,300	8,310
Consumption[8]	12,400 [r]	11,400 [r]	12,100 [r]	7,460 [r]	10,900
Stocks, December 31:					
Producer[9]	827	825	707	682	669
Consumer[8]	500 [r]	488 [r]	571 [r]	509 [r]	567
U.S. Government[2]	266	235	183	171	171
World, production of concentrate	56,600 [r]	53,500 [r]	62,300 [r]	61,000 [r]	68,800 [e]

[e]Estimated. [r]Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center). Data for 2006 include material committed for sale pending shipment; data for 2007–10 are uncommitted material only.

[3] Annual average calculated from weekly prices reported by Platts Metals Week.

[4] Annual average calculated from semiweekly prices reported by Metal Bulletin.

[5] Reported by tungsten processors.

[6] Annual average calculated from annual average high and low prices reported by Metal Bulletin for 2006 and from semiweekly prices reported by Metal Bulletin for 2007–10.

[7] Includes only tungsten metal powder and tungsten carbide powder.

[8] Includes ammonium paratungstate and other tungsten chemicals, ferrotungsten, tungsten metal powder, tungsten carbide powder, and tungsten scrap.

[9] Data exclude cast and crystalline tungsten carbide powder and chemicals.

TABLE 2

U.S. GOVERNMENT NATIONAL DEFENSE STOCKPILE TUNGSTEN STATISTICS IN 2010[1, 2]

(Metric tons of tungsten content)

	Inventory, yearend[3]		Annual	Sales		Inventory decrease[4]	
Material	Fiscal year[5]	Calendar year	Materials Plan[5]	Fiscal year[5]	Calendar year	Fiscal year[5]	Calendar year
Ores and concentrates	17,000	17,000	3,630	2,670	2,060	2,670	2,060
Tungsten metal powder	171	171	136	--	--	1	(6)
Total	17,200	17,200	3,760	2,670	2,060	2,670	2,060

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes stockpile- and nonstockpile-grade materials.

[3] Uncommitted inventory only. Does not include material committed for sale pending shipment.

[4] From previous year. Based solely on uncommitted yearend inventories.

[5] Twelve-month period ending September 30, 2010.

[6] Less than ½ unit.

Source: Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center).

TABLE 3

U.S. NET PRODUCTION AND STOCKS OF TUNGSTEN PRODUCTS[1, 2, 3]

(Metric tons of tungsten content)

	Tungsten metal powder	Tungsten carbide powder	Total
Net production:			
2009	2,880	2,420	5,300
2010	4,100	4,210	8,310
Producer stocks:			
December 31, 2009	379	304	682
December 31, 2010	341	328	669

[1] Net production equals receipts plus gross production less quantity used to make other products in table.

[2] Data are rounded to no more than three significant digits; may not add to totals shown.

[3] Data for cast and crystalline tungsten carbide powder and tungsten chemicals are withheld to avoid disclosing company proprietary data; not included in "Total."

TABLE 4

U.S. PROCESSORS OF TUNGSTEN IN 2010[1]

Company	Plant location
ATI Alldyne[2]	Huntsville, AL.
Buffalo Tungsten Inc.	Depew, NY.
Chem-Met Co., The	Clinton, MD.
Elmet Technologies, Inc.	Lewiston, ME.
General Electric Co.	Euclid, OH.
Global Tungsten & Powders Corp.[3]	Towanda, PA.
Kennametal Inc.	Fallon, NV.
Do.	Latrobe, PA.
Tungsten Diversified Industries LLC[4]	White Bear Lake, MN.[5]

Do. Ditto.

[1] Consumers of ammonium paratungstate, tungsten-bearing scrap, tungsten concentrates, and (or) tungsten oxides.

[2] An Allegheny Technologies Inc. company.

[3] A division of Plansee Group; formerly owned by Osram Sylvania Inc.

[4] Joint venture of North American Tungsten Corp. Ltd., Tundra Particle Technologies LLC, and Queenwood Capital Partners LLC.

[5] Pilot-scale operation.

TABLE 5

U.S. REPORTED CONSUMPTION AND STOCKS OF TUNGSTEN PRODUCTS[1,2,3]

(Metric tons of tungsten content)

	2009	2010
Consumption by end use:		
Steels	244	71
Superalloys	386 [r]	W
Other alloys[4]	W	W
Cemented carbides[5]	4,070	5,990
Mill products made from metal powder	W	W
Chemical uses	84	99
Total	7,460 [r]	10,900
Consumption by form:		
Ferrotungsten	246	129
Tungsten metal powder	2,610 [r]	W
Tungsten carbide powder	3,980	5,890
Tungsten scrap[6]	535	W
Other tungsten materials[7]	84	99
Total	7,460 [r]	10,900
Consumer stocks, December 31:		
Ferrotungsten	20 [r]	23
Tungsten metal powder	39 [r]	58
Tungsten carbide powder	387	414
Tungsten scrap[6]	49 [r]	61
Other tungsten materials[7]	13	11
Total	509 [r]	567

[r] Revised. W Withheld to avoid disclosing company proprietary data; included in "Total."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Does not include materials used in making primary tungsten products.

[3] Includes estimates.

[4] Includes welding and hard-facing rods and materials, wear- and corrosion-resistant alloys, and nonferrous alloys.

[5] Includes diamond tool matrices, cemented and sintered carbides, and cast carbide dies or parts.

[6] Includes tungsten bars.

[7] Includes tungsten chemicals.

TABLE 6

U.S. EXPORTS OF TUNGSTEN ORES AND CONCENTRATES, BY COUNTRY[1]

	2009			2010		
	Quantity			Quantity		
Country of destination	Gross weight (metric tons)	Tungsten content[2] (metric tons)	Value (thousands)	Gross weight (metric tons)	Tungsten content[2] (metric tons)	Value (thousands)
Australia	(3)	(3)	$10	--	--	--
Brazil	2	1	38	(3)	(3)	$5
Canada	(3)	(3)	4	(3)	(3)	5
Chile	--	--	--	2	1	25
China	14	7	219	--	--	--
Colombia	--	--	--	1	(3)	10
Egypt	4	2	59	--	--	--
Germany	1	(3)	15	487	251	5,570
Guyana	--	--	--	(3)	(3)	5
India	--	--	--	11	5	116
Ireland	1	1	18	--	--	--
Israel	1	(3)	10	--	--	--
Italy	(3)	(3)	8	--	--	--
Korea, Republic of	(3)	(3)	6	--	--	--
Malaysia	8	4	168	9	5	254
Mexico	--	--	--	2	1	26
Peru	--	--	--	2	1	96
Singapore	--	--	--	1	(3)	23
Spain	18	9	176	--	--	--
United Arab Emirates	--	--	--	3	2	28
United Kingdom	(3)	(3)	10	4	2	60
Vietnam	24	12	340	15	7	225
Total	73	38	1,080	535	276	6,440

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Content estimated from reported gross weight.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 7

U.S. EXPORTS OF AMMONIUM PARATUNGSTATE, BY COUNTRY[1]

	2009		2010	
Country of destination	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Austria	18	$361	6	$49
Brazil	--	--	2	20
Germany	350	5,560	432	7,750
Hungary	2	28	44	581
India	1	10	26	230
Italy	2	14	2	21
Mexico	2	16	4	35
Netherlands	--	--	1	11
Switzerland	--	--	20	137
Taiwan	1	5	(2)	4
United Kingdom	--	--	(2)	4
Total	375	5,990	538	8,840

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8

U.S. EXPORTS OF TUNGSTEN METAL POWDERS, BY COUNTRY[1, 2]

	2009			2010		
	Quantity			Quantity		
Country of destination	Gross weight (metric tons)	Tungsten content[3] (metric tons)	Value (thousands)	Gross weight (metric tons)	Tungsten content[3] (metric tons)	Value (thousands)
Argentina	(4)	(4)	$10	3	2	$145
Australia	2	1	90	16	13	563
Austria	4	3	140	25	20	771
Belgium	--	--	--	8	6	193
Brazil	14	11	797	19	15	1,160
Canada	76	61	3,140	111	88	4,820
Chile	2	2	119	6	5	450
China	23	19	1,720	31	25	1,860
Czech Republic	(4)	(4)	3	20	16	637
Germany	155	124	9,010	558	446	17,600
Hungary	--	--	--	5	4	117
India	13	10	739	13	11	856
Ireland	4	3	187	4	3	172
Israel	3	2	268	1	1	124
Japan	10	8	922	17	14	1,140
Korea, Republic of	5	4	403	5	4	344
Mexico	14	12	629	28	22	878
Netherlands	25	20	765	43	34	941
Norway	--	--	--	1	1	33
Oman	1	1	47	1	1	82
Peru	2	2	133	5	4	238
Saudi Arabia	(4)	(4)	19	6	5	494
Singapore	18	14	1,610	18	14	1,680
South Africa	2	2	126	8	6	542
Switzerland	2	2	187	9	8	868
Taiwan	12	10	849	19	15	1,430
Thailand	(4)	(4)	12	2	2	86
Turkey	2	2	129	3	2	231
United Arab Emirates	3	2	248	2	2	149
United Kingdom	15	12	969	9	7	401
Venezuela	1	1	71	8	6	376
Other	41 [r]	33 [r]	2,180 [r]	3	2	172
Total	450	360	25,500	1,000	803	39,600

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] May include tungsten alloy powders.

[3] Content estimated from reported gross weight.

[4] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9

U.S. EXPORTS OF TUNGSTEN CARBIDE POWDER, BY COUNTRY[1]

	2009		2010	
Country of destination	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Argentina	3	$56	1	$30
Australia	18	404	15	379
Austria	42	1,010	119	2,900
Belgium	2	234	39	313
Brazil	12	456	17	543
Canada	62	2,930	124	5,380
Chile	(2)	17	1	44
China	3	241	27	1,600
Colombia	2	141	3	85
Czech Republic	(2)	7	14	422
Denmark	1	50	3	106
France	7	476	34	1,070
Germany	125	6,080	235	9,290
Hong Kong	2	181	15	606
India	4	142	7	282
Indonesia	(2)	6	3	279
Ireland	26	773	27	919
Italy	(2)	12	1	94
Japan	8	253	13	894
Korea, Republic of	3	160	5	274
Mexico	2	130	8	585
Peru	1	68	5	305
Poland	13	677 r	1	41
Saudi Arabia	2	50	47	547
Singapore	9	380	6	369
South Africa	30	1,070	77	2,360
Sweden	1	96	15	495
Switzerland	(2)	12	5	243
Taiwan	32	1,180	61	2,440
Thailand	1	61	1	162
United Kingdom	38	1,280	262	9,150
Venezuela	7	402	24	1,230
Other	13 r	614 r	2	175
Total	469	19,600	1,220	43,600

[r] Revised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 10

U.S. EXPORTS OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS, BY COUNTRY[1]

Product and country of destination	2009 Quantity, tungsten content (metric tons)	2009 Value (thousands)	2010 Quantity, tungsten content (metric tons)	2010 Value (thousands)
Ferrotungsten and ferrosilicon tungsten:				
Canada	1	$24	(2)	$3
Mexico	1	26	--	--
United Kingdom	(2)	4	(2)	8
Total	1	55	(2)	11
Unwrought tungsten:[3, 4, 5]				
Belgium	--	--	103	467
Brazil	5	34	13	59
Canada	56	467	162	1,070
China	24	100	8	32
Colombia	--	--	4	17
Czech Republic	17	70	5	20
France	38	162	2	9
Germany	16	73	9	47
Hungary	18	85	15	66
Indonesia	2	7	19	84
Israel	1	3	4	19
Japan	(2)	12	8	38
Korea, Republic of	--	--	2	10
Malaysia	5	22	2	15
Mexico	6	25	44	191
Netherlands	--	--	12	176
New Zealand	(2)	6	3	15
Singapore	14	69	12	62
Switzerland	--	--	1	5
Taiwan	7	45	2	23
Thailand	1	3	1	3
United Kingdom	27	113	11	47
Other	42[r]	240[r]	(2)	4
Total	277	1,530	444	2,470
Waste and scrap:[4]				
Australia	--	--	7	58
Belgium	--	--	2	66
Brazil	--	--	11	378
Canada	29	341	92	947
China	181	3,290	132	2,860
Colombia	(2)	8	2	13
Czech Republic	--	--	5	141
Finland	61	1,500	306	3,800
France	--	--	3	94
Germany	190	3,080	218	4,340
Hong Kong	--	--	1	9
India	32	703	14	443
Ireland	--	--	1	6
Japan	19	159	11	93
Mexico	1	11	2	22
Netherlands	17	141	27	497
Singapore	1	8	6	51
Switzerland	(2)	3	3	24
Taiwan	31	558	8	69
United Arab Emirates	--	--	10	91

See footnotes at end of table.

TABLE 10—Continued

U.S. EXPORTS OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS, BY COUNTRY[1]

Product and country of destination	2009 Quantity, tungsten content (metric tons)	2009 Value (thousands)	2010 Quantity, tungsten content (metric tons)	2010 Value (thousands)
Waste and scrap—Continued:[4]				
United Kingdom	181	$1,570	55	$740
Other	237 r	2,060 r	(2)	3
Total	981	13,400	915	14,700
Wrought tungsten:[3, 4, 6]				
Australia	6	1,170	9	1,470
Belgium	1	68	6	599
Brazil	6	597	7	808
Canada	24	2,540	37	4,190
China	5	944	9	1,400
Colombia	2	369	2	545
Costa Rica	(2)	54	5	715
Czech Republic	16	2,240	27	3,450
Germany	35	5,070	82	7,570
Hungary	3	579	5	948
India	3	260	3	353
Indonesia	3	797	5	1,000
Italy	2	451	2	351
Japan	25	5,640	25	4,110
Mexico	17	3,090	17	3,190
Netherlands	3	787	4	926
Russia	2	232	2	164
Singapore	1	278	5	953
Spain	3	473	6	802
Sweden	7	1,860	9	2,240
United Kingdom	19	3,440	9	3,200
Other	16 r	2,100 r	13	2,320
Total	198	33,000	289	41,300
Tungsten compounds:[7]				
Canada	25	84	21	75
France	(2)	8	2	21
Germany	--	--	117	1,470
Malaysia	--	--	1	31
Other	42 r	458 r	1	14
Total	67	551	142	1,610

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

[3] May include alloys.

[4] Content estimated from reported gross weight.

[5] Includes bars and rods produced simply by sintering; excludes powders and waste and scrap.

[6] Includes bars and rods other than those produced simply by sintering; profiles, plates, sheets, strip, and foil; wire; and other wrought products.

[7] Includes only other tungstates.

Source: U.S. Census Bureau.

TABLE 11
U.S. IMPORTS FOR CONSUMPTION OF TUNGSTEN ORES AND CONCENTRATES, BY COUNTRY[1]

	2009		2010	
Country of origin	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Bolivia	891	$16,800	939	$18,500
Brazil	14	233	--	--
Canada	856	17,500	13	396
Germany	--	--	(2)	44
Guatemala	8	28	--	--
Kenya	20	356	--	--
Mexico	22	191	13	92
Mongolia	35	476	19	240
Peru	427	9,160	519	12,500
Portugal	756	18,100	635	15,900
Rwanda	216	3,470	79	1,290
Spain	196	4,250	215	5,510
Thailand	115	1,830	90	1,690
Uganda	12	245	94	1,810
United Kingdom	18	275	36	554
Vietnam	--	--	88	1,400
Total	3,590	72,900	2,740	60,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 12
U.S. IMPORTS FOR CONSUMPTION OF AMMONIUM PARATUNGSTATE, BY COUNTRY[1]

	2009		2010	
Country of origin	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
China	2,470	$51,000	2,410	$53,500
Germany	47	1,020	55	1,700
Hong Kong	--	--	3	56
United Kingdom	(2)	11	(2)	13
Vietnam	25	553	44	1,130
Total	2,540	52,600	2,510	56,400

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 13
U.S. IMPORTS FOR CONSUMPTION OF FERROTUNGSTEN AND FERROSILICON TUNGSTEN, BY COUNTRY[1]

	2009		2010	
Country of origin	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Australia	--	--	4	$110
China	23	$624	304	9,320
France	--	--	(2)	4
Luxembourg	--	--	15	535
Netherlands	--	--	15	419
Vietnam	23	641	19	634
Total	46	1,260	357	11,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 14
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS, BY COUNTRY[1]

Product and country of origin	2009 Quantity, tungsten content (metric tons)	2009 Value (thousands)	2010 Quantity, tungsten content (metric tons)	2010 Value (thousands)
Tungsten metal powders:[2]				
Austria	1	$26	2	$66
Canada	20	864	63	2,310
China	133	4,320	249	8,390
Germany	255	9,720	214	8,500
Israel	211	9,140	391	13,700
Japan	27	1,220	49	3,370
Korea, Republic of	187	6,960	374	13,500
Spain	(3)	44	2	129
Other	3 [r]	126 [r]	1	54
Total	837	32,400	1,340	50,000
Tungsten carbide powder:				
Austria	6	114	14	483
Belgium	5	304	44	2,010
Canada	26	1,250	116	5,920
China	536	16,500	961	34,100
Czech Republic	23	904	49	2,540
France	4	351	5	353
Germany	54	4,270	127	8,040
Hong Kong	8	183	16	595
India	3	85	3	148
Israel	43	1,680	156	5,600
Korea, Republic of	12	494	17	707
Luxembourg	--	--	5	226
Singapore	--	--	5	77
Sweden	32	1,130	42	1,360
Vietnam	--	--	47	2,120
Other	1	77	1	262
Total	753	27,400	1,610	64,500
Unwrought tungsten:[2, 4, 5]				
Australia	--	--	3	48
China	475	12,000	310	9,170
Germany	3	229	2	210
Singapore	14	459	17	724
Other	(3)	71 [r]	4	234
Total	492	12,800	335	10,400
Waste and scrap:				
Austria	69	937	120	860
Brazil	--	--	3	39
Canada	14	194	20	485
Chile	1	16	12	286
China	252	6,250	142	4,020
Czech Republic	4	84	29	629
Germany	215	3,110	170	2,930
Hong Kong	9	197	37	1,010
India	8	47	47	974
Japan	19	377	32	702
Korea, Republic of	65	609	120	1,510
Luxembourg	--	--	318	4,970
Mexico	74	757	134	1,480
Pakistan	2	21	50	782

See footnotes at end of table.

TABLE 14—Continued
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS, BY COUNTRY[1]

Product and country of origin	2009		2010	
	Quantity, tungsten content (metric tons)	Value (thousands)	Quantity, tungsten content (metric tons)	Value (thousands)
Waste and scrap—Continued:				
Peru	2	$70	4	$164
Singapore	(3)	3	19	438
Switzerland	--	--	54	735
Taiwan	7	40	43	951
Thailand	8	97	60	946
United Kingdom	56	937	35	805
Other	73 r	946 r	2	43
Total	879	14,700	1,450	24,800
Wrought tungsten:[2, 4, 6]				
Austria	29	4,670	61	11,100
Belgium	7	967	7	948
China	364	15,500	568	24,100
Czech Republic	8	6,050	5	3,370
France	6	1,260	3	662
Germany	5	938	9	1,550
Hong Kong	4	308	5	424
Hungary	3	648	8	1,550
Japan	16	4,090	21	6,190
Mexico	2	218	2	146
Netherlands	4	842	3	479
Russia	1	73	10	1,140
South Africa	3	81	43	1,050
Sweden	1	480	4	1,110
Other	10 r	1,390 r	8	2,030
Total	462	37,500	759	55,900
Tungsten oxides:				
China	329	8,170	1,090	25,100
Czech Republic	--	--	12	487
Germany	5	167	8	263
Hong Kong	--	--	32	782
Israel	--	--	5	106
Taiwan	--	--	16	420
Vietnam	5	85	48	1,560
Other	42 r	1,070 r	(3)	19
Total	380	9,490	1,210	28,700
Other tungstates:				
China	1	30	41	1,050
India	4	112	8	216
Ireland	5	23	62	173
Other	7 r	190 r	1	187
Total	17	356	111	1,630
Other tungsten compounds:[7]				
China	--	--	1	37
Germany	3	159	(3)	244
Japan	1	392	4	975
Total	5	550	5	1,260

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] May include alloys.

[3] Less than ½ unit.

TABLE 14—Continued
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS TUNGSTEN-BEARING MATERIALS, BY COUNTRY[1]

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[4] Content estimated from reported gross weight.

[5] Includes bars and rods produced simply by sintering; excludes powders and waste and scrap.

[6] Includes bars and rods other than those produced simply by sintering; foil, plates, profiles, sheets, and strip; wire; and other wrought products.

[7] Includes tungsten chlorides.

Source: U.S. Census Bureau.

TABLE 15
TUNGSTEN: WORLD CONCENTRATE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, tungsten content)

Country[3]	2006	2007	2008	2009	2010[e]
Australia	15	7	28	33	16
Austria	1,153	1,117	1,122	887 [r]	1,000
Bolivia	868	1,107	1,148	1,023	1,204 [4]
Brazil	525	537	408	208 [r, e]	500
Burma[5]	197	183	136	87	90
Burundi	238	144	194	150 [r, e]	170
Canada	1,983	2,305	2,277	1,964	420 [4]
China[e, 6]	45,000	41,000	50,000	51,000	59,000
Congo (Kinshasa)[e, 7]	500	560 [r]	370 [r]	360 [r]	360
Korea, North[e, 8]	930	230	270	100	110
Mongolia	182	245	142	39	20
Peru[9]	50	366	456	502	571 [4]
Portugal	780	846	1,238 [r]	1,037 [r]	1,200
Russia[e]	2,800	3,400 [r]	3,000	2,300 [r]	2,800
Rwanda	1,000 [r]	920 [r]	670 [r]	450 [r]	440
Spain[e]	--	--	150	200 [r]	250
Thailand[e]	303	477	617	600	600
Uganda	75	86	50 [e]	20 [e]	25
United States	--	W	W	W	W
Total	56,600 [r]	53,500 [r]	62,300 [r]	61,000 [r]	68,800

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through May 22, 2011.

[3] Tungsten concentrates are thought to be produced in Mexico, Nigeria, Turkey, and Vietnam, and may be produced from tin-tungsten ores in Kyrgyzstan, but information is inadequate to make reliable estimates of production. Illegal tungsten (wolfram) mining in the Phuoc Trung Commune of the Bac Ai District, Ninh Thuan Province in Southern Vietnam reportedly was halted by the District People's Committee in April 2008.

[4] Reported figure.

[5] Includes tungsten content of tin-tungsten concentrate produced by state-owned mining enterprises under the Ministry of Mines.

[6] Based upon data published in the Yearbook of Nonferrous Metals Industry of China.

[7] Production estimated based on reported exports from Nord–Kivu and Sud–Kivu Provinces.

[8] Production estimated based on Chinese imports.

[9] Data for 2007–10 based on production reported by Malaga Inc.

VANADIUM

By Désirée E. Polyak

Domestic survey data and tables were prepared by Glenn W. Walker, statistical assistant, and the world production tables were prepared by Lisa D. Miller, international data coordinator.

In 2010, reported vanadium consumption in the United States was 5,000 metric tons (t) of contained vanadium, a 7% increase from that of 2009 (table 1). The United States exported 611 t of ferrovanadium (FeV), 140 t of vanadium pentoxide (V_2O_5), and 1,098 t of other oxides and hydroxides of vanadium collectively valued at $30.9 million. Total exports of these vanadium-bearing materials increased by 17% from those of 2009. The United States imported (measured in vanadium content) 1,340 t of FeV; 3,998 t of V_2O_5; and 167 t of other oxides and hydroxides of vanadium collectively valued at $98.2 million. Total imports for consumption of these vanadium materials increased by 267% from those of 2009.

Vanadium's primary use is as a hardening agent in steel, in which it is critical in imparting toughness and wear resistance. These properties are especially important in high-strength low-alloy steels. Catalysts represented the leading nonmetallurgical use for vanadium.

Secondary vanadium production from various industrial waste materials, such as vanadium-bearing fly ash, petroleum residues, pig iron slag, and spent catalysts, was the leading source of U.S. vanadium production. A small amount of vanadium was obtained as a coproduct from the mining of uraniferous sandstones on the Colorado Plateau. Fewer than 10 firms, primarily in Arkansas, Ohio, Pennsylvania, and Texas, processed waste materials to produce FeV, V_2O_5, and vanadium metal.

Production

The major vanadium commodities are aluminum-vanadium master alloys; FeV; vanadium-bearing ash, residues, and slag; vanadium chemicals; and V_2O_5 and other oxides and hydroxides of vanadium. In 2010, companies in the United States produced all of these materials with the exception of vanadium-bearing slag from the manufacture of iron and steel. Vanadium-containing steels can be subdivided into microalloy or low-alloy steels that generally contain less than 0.15% vanadium and high-alloy steels that contain as much as 5% vanadium.

Uranium production from carnotite ores creates a vanadium-bearing waste solution that must be neutralized to have the heavy metals fixed before waste disposal. An alternative treatment is a circuit which extracts vanadium and produces V_2O_5. Denison Mines Corp. (Toronto, Ontario, Canada) owns the White Mesa uranium processing mill near Blanding, UT. White Mesa processed feed from Denison's mine properties on the Colorado Plateau as well as uranium/vanadium ores purchased from independent miners. For every 0.45 kilogram (kg) of triuranium octoxide concentrate (yellowcake) produced, White Mesa's vanadium coproduct recovery circuit produced approximately 1.8 kg of vanadium in the form of V_2O_5. After being idle for more than one-half of 2009, the facility produced 1,060 t of V_2O_5 in 2010. According to the company, 541,000 pounds (lbs) (245 t) of V_2O_5 was sold at an average price of $6.44 per lb V_2O_5 and 1,003,000 lbs (455 t) of FeV at an average price of $13.40 per lb (Denison Mines Corp., 2011a, p. 5). Denison's vanadium production was projected to total approximately 770 t V_2O_5 in 2011 (Denison Mines Corp., 2011b). The company anticipated, except for scheduled maintenance shutdowns, that it would continue processing conventional ore during most of 2011 (Denison Mines Corp., 2011a, p. 11).

American Vanadium Corp.'s 100%-owned, open pit, heap-leach Gibellini project in Eureka County, NV, was expected to begin a feasibility study based on its preliminary economic assessment, under which mine production was projected to average 6,350 tons per year (t/yr) of V_2O_5. According to the company, mine production could begin as early as the first quarter of 2013, which would make American Vanadium the only primary vanadium mine in the United States (American Vanadium Corp., 2011).

Evraz Group S.A. (Moscow, Russia), an important vanadium producer, announced that its FeV production rose 68% in 2010 to 13,507 t of contained vanadium compared with 8,029 t of contained vanadium in 2009, following the acquisition of Vanady-Tula, a vanadium refinery in Russia in November 2009. Production of oxides, vanadium alumina and vanadium chemicals increased by 35% to 1,317 t compared with 976 t in 2009 (Ryan's Notes, 2011). Evraz comprises Evraz Highveld Steel and Vanadium in South Africa, Nikom in the Czech Republic, Strategic Minerals Corp. (Stratcor Inc.) in the United States and South Africa, and Vanady-Tula in Russia. Stratcor operates a facility in Hot Springs, AR, where vanadium ash, residues, and other raw materials are converted into vanadium alloys and vanadium chemicals used by the chemical, steel, and titanium industries.

AMG Vanadium Inc., formerly Metallurg Vanadium Corp., completed construction of a new $6 million storage facility as part of a long-term project to increase vanadium production capacity at its Cambridge, OH, facility. The building met all standards for safe containment of spent refinery catalyst, a raw material used in the production of FeV, the company's primary product offering. The building was linked to a dedicated railcar unloading and conveyor system, which was expected to enhance efficiency (AMG Vanadium Inc., 2010).

The Vanadium Technology Partnership estimated that approximately 2,700 t/yr of vanadium was recycled from spent catalysts (Vanadium Technology Partnership, undated). Vanadium's major end use was as an alloying-element in iron, steel, and titanium-bearing alloys, from which it is lost to slag and usually not recovered when those metals are recycled.

Consumption

The U.S. Geological Survey (USGS) derived vanadium consumption data from a voluntary survey of domestic consuming companies. For this survey, more than 80 companies were canvassed on a monthly or annual basis. Based on USGS data, reported domestic vanadium consumption in 2010 was 5,000 t, a 7% increase from that of 2009.

Metallurgical applications continued to dominate U.S. vanadium use in 2010, accounting for 95% of reported consumption. Nonmetallurgical applications included catalysts, ceramics, electronics, and vanadium chemicals. The dominant nonmetallurgical use was in catalysts.

Most vanadium is consumed in the form of FeV, which is used as a means of introducing vanadium into steel, in which it provides additional strength and toughness. FeV is available as alloys containing either 45% to 50%, or 80% vanadium. The 45%- to 50%-grade FeV is produced by silicothermic reduction of V_2O_5 in slag or other vanadium-containing materials. Most of the 80%-grade FeV is produced by aluminothermic reduction of V_2O_5 in the presence of steel scrap or by direct reduction in an electric arc furnace.

Prices

In 2010, the price for domestic FeV, as published in Metal Bulletin, ranged from $10.50 to $17.25 per pound of contained vanadium, compared with $7.40 to $35.00 per pound reported in 2009. In January, prices averaged $11.40 per pound. Prices increased to a monthly high of $17.25 in May and gradually decreased to end the year at an average of $13.50 per pound in December. The European FeV price ranged from $21.00 to $34.50 per kilogram compared with $17.50 to $36.00 per kilogram in 2009. The European price averaged $26.22 per kilogram in January and gradually increased to a monthly high of $34.50 per kilogram in May. The price decreased in June and continued to slowly decrease for the remainder of the year to an average of $29.24 per kilogram in December.

The Metal Bulletin published price for domestic V_2O_5 ranged between $6.00 and $7.85 per pound in 2010, compared with $3.60 and $7.60 per pound in 2009. The price averaged about $6.35 per pound in January and increased to a monthly high of $7.85 per pound in May. Prices slowly decreased the rest of the year to end the year with an average of $6.60 in December.

World Review

A large majority of the world's supply of vanadium was derived from mined ore, either directly as mineral concentrates derived from vanadiferous titanomagnetite (VTM) or from steelmaking slags, where the steel has been produced from VTM. Five countries recovered vanadium from ores, concentrates, slag, or petroleum residues (table 7). The leading vanadium-producing nations remained China, Russia, and South Africa. Japan and the United States were thought to be the only countries to recover significant quantities of vanadium from petroleum residues.

World vanadium reserves, at more than 13 million metric tons (Mt), are sufficient to meet vanadium needs into the next century at the present rate of consumption. Increased recovery of vanadium from fly ash, petroleum residues, slag, and spent catalyst is not taken into account and is expected to extend the life of the reserves significantly.

Australia.—Atlantic Ltd. (Perth) announced in September that vanadium production was expected to begin in mid-2011 at its newly acquired Windimurra vanadium project in Western Australia, following raising $55.5 million in capital. The previous owners of the project failed to secure the necessary $81 million financing in 2009. According to Atlantic, Windimurra production was expected to be 5,700 t/yr of V_2O_5 and to meet approximately 7% of world demand. According to the current mine plan for the project, at a cutoff grade of 0.275% V_2O_5, 97.8 Mt of ore was expected to be generated at an average grade of 0.47% V_2O_5 during 24.5 years (Atlantic Ltd., 2010).

In November, Reed Resources Ltd. (West Perth) announced that it entered into a memorandum of understanding (MOU) with Chinese conglomerate, China Nonferrous Metal Industry's Foreign Engineering and Construction Co. Ltd. (NFC), for the Barrambie vanadium project in Western Australia. According to the company, the MOU formalizes discussions between Reed and NFC, specifically construction, an engineering procurement, and project financing, and represents the next step towards the successful development of the project (Reed Resources Ltd., 2010).

Brazil.—Largo Resources Ltd. (Toronto, Ontario, Canada) has completed extensive work on its Maracas vanadium project including a feasibility study which outlined proven and probable mineral reserves of 13.1 Mt grading 1.34% V_2O_5 produced during a 23-year project life-span. The Maracas vanadium project was expected to produce 5,000 t/yr of FeV. The property is located in the municipality of Campo Alegre de Lourdes, State of Bahia (Largo Resources Ltd., 2010).

Canada.—Apella Resources Inc. (Vancouver, British Columbia) owns two vanadiferous magnetite deposits in Canada, the Iron-T vanadium project in central Quebec and the Lac Dore vanadium project in northern Quebec. According to the company, the Lac Dore project is an advanced vanadium project and was expected to be the largest vanadium deposit in North America, and the second largest in the world (Apella Resources, 2011b). Apella was expected to continue exploration and development on the Lac Dore project into 2011. Simultaneously, Apella was expected to study the feasibility of its Iron-T vanadium project, which was expected to take 12 to 18 months and cost approximately $18 million (Apella Resources, 2011a).

China.—The Chinese vanadium industry continued to feel pressure from niobium, particularly in high-strength low-alloy steels (HSLA). The additive amount of niobium in steel production is only one-half of that of vanadium, so every 3,000 t of ferroniobium can substitute as much as 7,000 t of 50% grade FeV (Metal-Pages, 2010). The substitution of ferroniobium however, is only economic at very high vanadium prices.

Sino Vanadium Inc. (Xi'an) owns 100% of the Daquan property in Shaanxi Province, and according to the company, the property was expected to become one of the largest global producers of V_2O_5, with indicated resources of 15.8 Mt at an average grade of 0.95% V_2O_5. In advance of completion of the feasibility study for the project, the company was proceeding with the necessary applications to the Chinese government authorities to amend the Daquan project mining license, valid to July 2, 2030, to include both open pit and underground mining. The feasibility study was expected to confirm the construction schedule, which was anticipating completion in the second quarter of 2012 (Sino Vanadium Inc., 2010).

India.—The Indian Ferro Alloy Producers Association continued to urge the Indian Finance Ministry to reconsider the 7.5% import tax on V_2O_5 and vanadium sludge/ammonium metavanadate. They have asked that the tax be removed completely to protect the domestic FeV producers from completely shutting down their operations owing to lack of profits caused by the excessive costs of importing the raw material (V_2O_5) (Indian Ferro Alloy Producers Association, 2011).

Japan.—Japan's vanadium imports increased in 2010 compared with those in 2009; however, they have not recovered to 2008 levels. Japan's imports of V_2O_5 rose to 1,382 t V_2O_5 compared with 942 t V_2O_5 for the same period in 2009. Japanese FeV production increased to 2,825 t FeV in the first 8 months of 2010, up from 1,362 t FeV in the same period in 2009 and 2,620 t FeV in the same period of 2008 (Ryan's Notes, 2010).

Madagascar.—In November, Energizer Resources Inc. (Toronto, Ontario, Canada), formerly known as Uranium Star Corp., updated the resource estimate for its Green Giant vanadium project in Madagascar to include an indicated resource of 49.5 Mt at an average grade of 0.693% V_2O_5. The mineral resource is contained in three separate zones on the Green Giant property, totaling approximately 5.3 kilometers (km) in strike length. According to the company, a preliminary economic assessment, to include analysis of the existing and additional infrastructure necessary for the project, was to begin in 2011. One important and potential benefit to the company would be the development of the adjacent Sakoa coal project, situated 30 km away from the Green Giant project (Energizer Resources Inc., 2011).

According to the company, the Green Giant vanadium deposit is a sedimentary-hosted deposit, in contrast to most vanadium deposits which are magnetite hosted. As a result, the metallurgical process for the Green Giant vanadium is different from that used by other vanadium producers. The unique characteristics of the Green Giant vanadium would allow the company to produce a high-purity V_2O_5, which is required in battery power and in battery storage for both automotive and large-scale applications. FeV, which is the usual end product from magnetite-hosted deposits, can only be used for steel applications (Energizer Resources Inc., 2011).

Russia.—Evraz announced that it focused on increasing the efficiency of its Vanady-Tula plant, and upon implementation of its plan, the plant's production capacity was expected to increase by 3% to 5% in 2011 and by up to 10% by 2013. In 2011, Vanady-Tula had a capacity to produce 12,500 t/yr of V_2O_5 and up to 7,100 t/yr of FeV (Evraz Group S.A., 2011, p. 45).

South Africa.—Xstrata plc (Zug, Switzerland) announced that its Rhovan vanadium facility, located 30 km northwest of Brits, achieved record production during 2010. The Rhovan facility produced 4,300 t of FeV in 2010, an 89% increase compared with 2,280 t of FeV produced in 2009. The facility produced 9,920 t of V_2O_5 in 2010, a 90% increase compared with 5,210 t of V_2O_5 produced in 2009. In part of 2009, the facility suspended all vanadium production owing to an extended maintenance program (Xstrata plc, 2011).

Vametco Alloys (Brits), a division of Stratcor, part of Evraz, announced that it improved production efficiency at its Vametco plant through optimizing the feed mix of vanadium ore and vanadium slag to its process. Vametco was therefore able to raise its production to full capacity during the second half of 2010. Vametco's primary end product is Nitrovan vanadium, a specialty vanadium-nitrogen alloy, which according to the company, strengthens steel more efficiently than FeV. The company was expected to continue to improve its vanadium recovery rate in 2011 as well as perform several safety improvements and environmental projects (Evraz S.A., 2011, p. 45).

Evraz Highveld Steel and Vanadium Ltd. (Emalahleni) reported producing 64,202 t of vanadium slag in 2010, a 38% increase from 46,614 t of vanadium slag produced in 2009. The company mines titaniferous magnetite ore at its Mapochs Mine at Roossenekal, Limpopo, and produces iron and steel products and vanadium bearing slag at its Steelworks facility in Emalahleni, Mpumalanga. The company marketed the vanadium-bearing slag locally as well as in Europe through its Austrian-based subsidiary, Hochvanadium Holdings AG (Evraz Highveld Steel and Vanadium Ltd., 2011, p. 5, 7).

Outlook

Vanadium consumption is heavily influenced by steel production, high-strength steel grades in particular. In 2010, vanadium benefited from an improvement in the global economy and a consequent improvement in the demand for steel. High-strength steels are growing in use as the construction, energy, and transportation industries seek to maximize the strength and minimize the weight of their products. There continues to be growth potential in vanadium's other end-use industries as well. Aerospace applications are rapidly expanding, and vanadium consumption has been increasing with the introduction of the next generation of commercial aircraft. The quest for fuel efficiency is key in the aerospace industry but also extends to automobiles, high-speed drilling, powerplants, and rail cars.

There are several different battery technologies in the development and early commercialization stages. One technology showing continued promise in stabilizing energy distribution in renewable systems is the vanadium redox battery (VRB), which consists of an assembly of power cells in which two vanadium-based electrolytes are separated by a proton exchange membrane. The main advantages of the VRB are that it can offer almost unlimited capacity simply by using sequentially larger storage tanks, can be left completely discharged for long periods of time with no ill effects, can be recharged by replacing the electrolyte if no power source is available to charge it, and suffers no permanent damage if the electrolytes are accidentally mixed (Johnstone, 2008). The VRB has also been shown to have the least ecological impact of all energy storage technologies.

Another emerging technology is the use of lithium-vanadium phosphate or fluorophosphate cathodes and lithium-vanadium oxide anodes in rechargeable lithium batteries. These batteries exhibit much improved safety compared with the more generic lithium-cobalt oxide type cathodes seen in cellular telephone or laptop batteries, which have higher operating voltages and higher rates of energy storage. The vanadium phosphate cathode material can support 20% more energy storage than the conventional cobalt oxide, as much as 26% more than iron phosphate, and 56% more than manganese oxide. However, in order for such a battery to be practical, the cost of the battery is key. Subaru, owned by Fuji Heavy Industries Ltd., has unveiled a prototype of its G4e electric car, powered by lithium-vanadium phosphate batteries. This concept car has a 200-km range that is provided by a relatively small vanadium phosphate battery pack, double what their earlier R1e concept car could achieve (Hykawy, 2009).

Vanadium is also emerging as an anticorrosion agent in some rare-earth magnets, enabling use of a new set of materials for use in strong magnets. Vanadium acts to increase the effectiveness of rare-earth magnets, including making the magnets much more resistant to corrosion across a broader range of temperature and humidity (Hykawy, 2009).

The outlook for the vanadium market in 2011 appears to be strong. Increasing steel demand, projected through at least 2015, mandates for higher quality steel in emerging markets, and the potential for a whole new market for battery production, were all expected to contribute to increased vanadium consumption.

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TABLE 1
SALIENT VANADIUM STATISTICS[1]

(Metric tons of contained vanadium, unless otherwise specified)

	2006	2007	2008	2009	2010
United States:					
Production, ore and concentrate:					
Recoverable vanadium	--	--	W	W	W
Recoverable vanadium:[2] value thousand dollars	--	--	W	W	W
Consumption, reported	4,030	4,970 [r]	5,170	4,690 [r]	5,030
Exports:					
Ferrovanadium	515 [r]	206 [r]	452 [r]	672	611
Vanadium pentoxide (anhydride)	341	327	249	401	140
Other oxides and hydroxides of vanadium	832	626	1,040	506	1,100
Imports for consumption:					
Ferrovanadium	2,140 [r]	2,220 [r]	2,800 [r]	353	1,340
Ash and residues[3]	637	1,000	1,040	791	521
Vanadium pentoxide (anhydride)	1,920	2,390	3,700	1,120	4,000
Other oxides and hydroxides of vanadium	129	42	144	25	167
Stocks:					
Ferrovanadium	275	253	229 [r]	232	181
Oxide	6	22	24	5	5
Other[4]	49	49 [r]	82 [r]	58	62
World, production from ore, concentrate, slag[e, 5]	57,900	58,500	56,400	51,400 [r]	57,600

[e] Estimated. [r] Revised. W Withheld to avoid disclosing company proprietary data. -- Zero.

[1] Data are rounded to no more than three significant digits.

[2] Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mill, plus vanadium recovered from ferrophosphorous slag derived from domestic phosphate rock.

[3] Ash and residues from the manufacture of iron and steel.

[4] Consists principally of vanadium-aluminum alloy, small quantities of other vanadium alloys, vanadium metal, and ammonium metavanadate.

[5] Excludes U.S. production.

TABLE 2

U.S. CONSUMPTION OF VANADIUM, BY END USE AND FORM[1]

(Kilograms of contained vanadium)

	2009	2010
End use:		
Steel:		
Carbon	832,000	843,000
Full alloy	1,920,000	2,030,000
High-strength low-alloy	W	W
Stainless and heat resisting	119,000	120,000
Tool	W r	W
Total	2,870,000 r	2,990,000
Cast irons	W	W
Superalloys	11,500 r	9,230
Alloys (excluding steels and superalloys):		
Welding and alloy hard-facing rods and materials	W	W
Other alloys[2]	W	W
Chemical and ceramic uses:		
Catalysts	W	W
Pigments	W	W
Miscellaneous and unspecified	1,800,000 r	2,030,000
Grand total	4,690,000 r	5,030,000
Form:		
Ferrovanadium	3,910,000 r	4,210,000
Oxide	44,300 r	3,530
Other[3]	732,000 r	815,000
Total	4,690,000 r	5,030,000

r Revised. W Withheld to avoid disclosing company proprietary data; included with "Miscellaneous and unspecified."

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes magnetic alloys.

[3] Consists principally of vanadium-aluminum alloy, small quantities of other vanadium alloys, vanadium metal, and ammonium metavanadate.

TABLE 3

U.S. IMPORTS AND EXPORTS OF ALUMINUM-VANADIUM MASTER ALLOY AND VANADIUM METAL, INCLUDING WASTE AND SCRAP[1]

	Aluminum-vanadium master alloy		Vanadium metal, including waste and scrap	
	Quantity, gross weight (kilograms)	Value	Quantity, gross weight (kilograms)	Value
Imports for consumption:				
2009	282,000	$979,000	21,700	$940,000
2010:				
China	494	2,500	4,370	93,100
Germany	--	--	5,300	341,000
Mexico	9,170,000	20,000,000	--	--
Netherlands	17,300	69,100	--	--
United Kingdom	16,400	109,000	--	--
Total	9,200,000	20,200,000	9,660	434,000
Exports:				
2009	11,200,000	27,800,000	22,700	1,040,000
2010:				
Belgium	80,600	1,320,000	--	--
Canada	7,320,000	17,400,000	2,280	74,600
Chile	--	--	28	2,880
China	16,500	164,000	--	--
Colombia	271	3,530	--	--
France	319	4,150	--	--
Germany	401	7,660	108	5,420
Hong Kong	657	19,300	--	--
India	17,900	160,000	--	--
Israel	6,840	102,000	--	--
Italy	637	8,280	--	--
Japan	55,300	1,600,000	18,100	572,000
Korea, Republic of	3,160	80,100	--	--
Malaysia	3,150	40,900	--	--
Mexico	4,180,000	11,200,000	--	--
Netherlands	296	3,850	--	--
Panama	--	--	129	6,280
Russia	793	8,040	--	--
Singapore	480	6,230	--	--
South Africa	1,430	14,400	--	--
Taiwan	32,700	101,000	--	--
Trinidad and Tobago	37,600	182,000	572	9,880
Turkey	804	10,500	--	--
United Arab Emirates	147,000	701,000	--	--
United Kingdom	7,350	107,000	--	--
Total	11,900,000	33,300,000	21,200	671,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS AND EXPORTS OF FERROVANADIUM, VANADIUM PENTOXIDE (ANHYDRIDE), AND OTHER OXIDES AND HYDROXIDES OF VANADIUM[1]

	Ferrovanadium		Vanadium pentoxide (anhydride)[2]		Other oxides and hydroxides of vanadium	
	Quantity, V^3 content (kilograms)	Value	Quantity, V^3 content (kilograms)	Value	Quantity, V^3 content (kilograms)	Value
Imports for consumption:						
2009	353,000	$12,600,000	1,120,000	$16,500,000	25,200	$551,000
2010:						
Albania	16,000	349,000	--	--	--	--
Australia	20,400	687,000	--	--	--	--
Austria	451,000	14,100,000	170	9,830	33,500	942,000
Canada	477,000	15,100,000	--	--	--	--
China	502	23,600	162,000	3,980,000	--	--
Germany	2,350	161,000	--	--	--	--
India	542	35,600	--	--	--	--
Korea, Republic of	372,000	10,600,000	--	--	--	--
Russia	--	--	2,520,000	29,900,000	--	--
South Africa	--	--	1,310,000	19,800,000	133,000	2,370,000
United Kingdom	--	--	3,000	39,700	5	22,600
Total	1,340,000	41,100,000	4,000,000	53,700,000	167,000	3,330,000
Exports:						
2009	672,000	15,000,000	401,000	4,970,000	506,000	5,270,000
2010:						
Argentina	1,450	44,500	1,530	48,100	48,300	283,000
Australia	393	13,100	--	--	--	--
Austria	--	--	--	--	32,500	289,000
Belgium	--	--	1,980	39,300	--	--
Brazil	--	--	20,500	256,000	24,900	222,000
Canada	310,000	9,690,000	--	--	223,000	2,100,000
China	13,700	243,000	--	--	42,300	400,000
Columbia	331	7,390	--	--	--	--
Germany	--	--	12,000	197,000	43,800	510,000
India	104,000	2,480,000	--	--	--	--
Ireland	--	--	--	--	4,470	39,800
Japan	--	--	--	--	558	4,970
Korea, Republic of	66,500	2,130,000	--	--	--	--
Mexico	56,200	1,930,000	1,290	28,600	37,700	493,000
Morocco	--	--	433	14,100	--	--
Netherlands	13,500	263,000	65,500	975,000	346,000	3,670,000
Pakistan	--	--	1,100	18,000	--	--
Peru	3,420	153,000	--	--	--	--
Russia	--	--	--	--	219,000	1,950,000
Saudi Arabia	15,000	478,000	10,400	183,000	--	--
Senegal	--	--	--	--	75,400	672,000
Singapore	--	--	225	9,320	--	--
Spain	--	--	19,000	247,000	--	--
Trinidad and Tobago	--	--	6,170	121,000	--	--
United Arab Emirates	25,900	698,000	--	--	--	--
Total	611,000	18,100,000	140,000	2,140,000	1,100,000	10,600,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] May include catalysts that contain vanadium pentoxide.

[3] Vanadium.

Source: U.S. Census Bureau.

TABLE 5
U.S. IMPORTS FOR CONSUMPTION OF VANADIUM-BEARING ASH AND RESIDUES[1]

Material and country	2009 Quantity, V_2O_5[2] content (kilograms)	2009 Value	2010 Quantity, V_2O_5[2] content (kilograms)	2010 Value
Ash and residues:[3]				
Belgium	--	--	48,700	$274,000
Canada	2,250	$4,850	89,800	69,800
Mexico	788,000	12,300,000	361,000	5,190,000
Saudi Arabia	--	--	6,090	31,200
Trinidad and Tobago	--	--	15,400	4,710
United Kingdom	120	2,210	--	--
Total	791,000	12,300,000	521,000	5,570,000

-- Zero

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] V_2O_5 Vanadium pentoxide.

[3] Ash and residues from the manufacture of iron and steel.

Source: U.S. Census Bureau.

TABLE 6
U.S. IMPORTS FOR CONSUMPTION OF MISCELLANEOUS VANADIUM CHEMICALS[1, 2]

Material and country	2009 Quantity, V[3] content (kilograms)	2009 Value	2010 Quantity, V[3] content (kilograms)	2010 Value
Sulfates, China	16,500	$182,000	46,400	$575,000
Vanadates:				
Austria	--	--	410	13,700
China	167	3,250	25,600	887,000
Germany	12,500	473,000	61,700	1,990,000
India	137	12,100	390	7,790
Japan	--	--	214	44,000
South Africa	182,000	2,550,000	69,500	1,100,000
Taiwan	--	--	293	10,200
United Kingdom	19,800	352,000	--	--
Total	214,000	3,390,000	158,000	4,050,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Comprises vanadium ore and miscellaneous vanadium chemicals.

[3] Vanadium.

Source: U.S. Census Bureau.

TABLE 7
VANADIUM: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, vanadium content)

Country	2006	2007	2008	2009	2010
Production from ores, concentrates, slag:[3]					
China[4]	17,500	19,000	20,000	21,000	22,000
Kazakhstan	1,000	1,000	1,000	1,000	1,000
Russia	15,100	14,500	14,500	14,500	15,000
South Africa	23,780 [5]	23,486 [5]	20,295 [5]	14,353 [r, 5]	19,000
United States	--	--	W	W	W
Total	57,400	58,000	55,800	50,900 [r]	57,000
Japan, petroleum residues, ash, and spent catalysts[6]	560	560	560	560	560
Grand total	57,900	58,500	56,400	51,400 [r]	57,600

[r] Revised. W Withheld to avoid disclosing company proprietary data; not included in totals. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] In addition to the countries listed, vanadium is also recovered from petroleum residues in Germany and several other European countries, but available information is insufficient to make reliable estimates. Table includes data available through May 18, 2011.

[3] Production in this section is credited to the country that was the origin of the vanadiferous raw material.

[4] Estimated 40% of vanadium recovered from vanadiferous slag.

[5] Reported figure.

[6] Production in this section is credited to the country where the vanadiferous product is extracted; available information is inadequate to permit crediting this output back to the country of origin of the vanadiferous raw material.

VERMICULITE

By Arnold O. Tanner

Domestic survey data and tables were prepared by Raymond I. Eldridge III, statistical assistant, and the world production ible was prepared by Lisa D. Miller, international data coordinator.

In 2010, the domestic vermiculite industry showed signs f recovery from the economic recession that started in late 008 with a substantial increase in vermiculite concentrate roduction compared with that of 2009, although reportable roduction of vermiculite concentrate in 2010 remained at an stimated 100,000 metric tons (t), which was rounded to the earest 100,000 t to avoid disclosing company proprietary data. Vorldwide vermiculite production increased to approximately 40,000 t in 2010, up about 5% from that of 2009. About 3,000 t of exfoliated vermiculite was sold or used in the Inited States in 2010, up from 69,000 t in 2009. U.S. exports of ermiculite were estimated to be approximately 2,000 t, down om about 3,000 t in 2009, and U.S. imports were estimated to e 29,000 t, 26% less than those of 2009.

egislation and Government Programs

As a result of an estimated 400 deaths and more than 1,700 eople treated for sicknesses attributed to asbestos-related iseases in the town of Libby, MT, and the surrounding region, esearch regarding vermiculite contaminated with amphibole ontinued in this area, the locality of what was once the largest ermiculite mine in the world (Hart and others, 2009; Brown, 011; Frasca, 2011). Studies on the Libby vermiculite mine, vhich closed in 1990, continued in 2010 leading to a proposed ettlement in October. The State of Montana was in the final tages of negotiating a $43 million settlement with those ffected. More than 1,100 claimants with asbestos-related iseases would get a portion of the settlement in exchange or releasing the State and various State agencies from future laims related to the former vermiculate mine in Libby. For he settlement to be final, court approval was required, which vas not achieved by yearend. A ruling on the settlement was xpected in 2011 (Hintze, 2011).

roduction

Vermiculite is a hydrated magnesium-aluminum-iron ilicate; flakes of raw vermiculite concentrate are mica-like n appearance, contain water molecules within their internal tructure, and range in color from black to various shades f brown to yellow. When the flakes are heated rapidly to a emperature of 900 °C or higher, the water flashes into steam, nd the flakes expand into accordion-like particles, gold or ronze in color. This expansion process is called exfoliation, nd the resulting lightweight material is chemically inert, fire esistant, and odorless. Two U.S. producers of vermiculite oncentrate, Virginia Vermiculite LLC with two operations—ne near Woodruff, SC, and one in Louisa County, VA—and W.R. Grace & Co. from its operation at Enoree, SC, produced n estimated 100,000 t of vermiculite in 2010. Domestic production (sold or used) data for vermiculite were collected by the U.S. Geological Survey (USGS) from two voluntary canvasses—one for mine-mill (concentrator) operations and the other for exfoliation plants. Production data for nonrespondents were estimated based upon previous years' reported production levels.

Vermiculite concentrate was shipped to exfoliating plants for conversion into the expanded lightweight products. The output of about 73,000 t of exfoliated vermiculite sold or used by producers was valued at $41.2 million in 2010, up from $33.6 million in 2009 (table 1). Exfoliated vermiculite, produced from domestic and imported vermiculite concentrate, was produced by 14 companies operating 17 plants in 10 States (table 2). Of the 17 exfoliation plants, 9 responded to the annual canvass, representing 57% of the estimated sold or used exfoliated vermiculite tonnages listed in tables 1 and 3. States that produced exfoliated vermiculite were, in descending order of estimated output sold or used, South Carolina, New Jersey, Pennsylvania, Florida, Arizona, Massachusetts, Illinois, New Mexico, Ohio, and Arkansas.

Consumption

Vermiculite has a wide range of uses that take advantage of its various attributes of fire resistance, low thermal conductivity, high liquid absorption capacity, inertness, and low density (table 3). In lightweight aggregate applications, vermiculite is used in general building plasters and concrete products for its lightweight and good thermal insulation properties, alone or combined with other lightweight aggregates such as perlite. Special plasters include fire protection and soundproofing through products in which vermiculite is combined with a binder, such as gypsum or portland cement, fillers, and specialized additives (Roskill Information Services Ltd., 2004, p. 103). Vermiculite can absorb liquids, such as fertilizers, herbicides, and insecticides, which can then be transported as free-flowing solids.

As insulation, exfoliated vermiculite, sometimes treated with a water repellent, is used to fill pores and cavities in masonry construction and hollow blockwork to enhance acoustic properties, fire rating, and insulation performance. Finer grades of exfoliated vermiculite, combined with potassium or sodium silicate, are used to produce insulation shapes. The ability of vermiculite-base insulation shapes to resist attack by molten aluminum makes them especially useful as secondary insulation in the aluminum production process (Roskill Information Services Ltd., 2004, p. 112).

In horticulture, exfoliated vermiculite improves soil aeration and moisture retention. When vermiculite is mixed with peat or other composted materials, such as pine bark, the resulting product provides a good growing medium for plants. As a soil conditioner, exfoliated vermiculite can improve the aeration of "sticky" soils (containing clay) and the water retention characteristics of sandy soils. This allows for easier watering and reduces the likelihood of compaction, cracking, and crusting of the soil. Vermiculite is used in the fertilizer/pesticide market because of its ability to act as a bulking agent, carrier, and extender (Roskill Information Services Ltd., 2004, p. 108–109).

Other uses include refractory-insulation gunning and castable mixes and vermiculite dispersions. Finer grades of exfoliated vermiculite are used to partially replace asbestos in brake linings, primarily for the automotive market (Roskill Information Services Ltd., 2004, p. 112–113).

Prices

Published prices for vermiculite serve only as a general guide because of variations in application, quantity, source, and other factors. U.S. domestic prices for vermiculite concentrate, ex-plant, ranged from $95 to $400 per metric ton, largely dependent on grade sizing. The average value of imports into the United States, f.o.b. (free on board) barge Gulf Coast port, ranged from $210 to $460 per ton (Moeller, 2010). Coarser grained vermiculite with greater thermal expansion commands a higher price, but none is produced in the United States.

The average unit value of U.S. exfoliated vermiculite sold or used by producers, using actual and estimated data, was about $564 per ton in 2010, up by 16% from about $487 per ton in 2009; this was a composite value that included exfoliated vermiculite produced from both U.S. and imported concentrate (table 1).

Foreign Trade

Trade data for vermiculite concentrate are not collected as a separate category by the U.S. Census Bureau but are included within the category "vermiculite, perlite, and chlorite, unexpanded" under Harmonized Tariff Schedule of the United States code 2530.10.0000. Trade data in this report are from PIERS, a U.S. trade database compiled by the Journal of Commerce (United Business Media Global Trade, 2011). Total U.S. imports of vermiculite in 2010—crude, concentrate, and exfoliated—(excluding any material from Canada and Mexico) were estimated to be about 29,000 t, the majority of those coming from South Africa, about 67%; Brazil, 14%; and China, 12%. Total U.S. exports of about 2,000 t were shipped to the United Kingdom, 66%; Israel and Latvia, about 7% each; and Honduras, about 6%, with the remainder to several other countries.

World Review

Brazil.—In 2010, Brazil Minerios Ltda. produced 35,000 t of vermiculite at its Sao Luis De Montes Belos Mine near Goiania in central Brazil. With estimated reserves of 1.2 million metric tons (Mt) of vermiculite ore, Brasil Mineros planned increases in production capacity to 55,000 metric tons per year (t/yr) of vermiculite in 2011 and to 80,000 t/yr by 2013 (Elliott, 2011c).

China.—As part of group restructuring, Imerys (Paris, France) achieved a portion of its cost savings during the year, by significantly reducing production and temporarily withdrawing from vermiculite activities at the company's Xinlong Mine in the Xinjiang Province, along with taking a depreciation of mining rights at the operation (Imerys, 2011, p. 5). Imerys was the world's second-ranked supplier of vermiculite, with production also from deposits mainly in Australia and Zimbabwe.

South Africa.—In 2010, South Africa was the world's leading producer and exporter of crude vermiculite, accounting for about 198,000 t, or 37%, of an estimated world production of 540,000 t (table 4). From 2000–09, on average, 89% of the crude vermiculite produced in South Africa was exported (Directorate Mineral Economics, 2011). From its mine in Limpopo Province, Palabora Mining Co. Ltd. (a member of Rio Tinto plc) managed the world's largest vermiculite reserves. Palabora Mining reported 196,000 t of vermiculite production in 2010 (Palabora Mining Co. Ltd., 2011). Palabora Mining was finding it increasingly challenging to produce sufficient quantities of coarse-grained grades from its diminishing resources to help meet substantially increasing world demand (Elliott, 2011c).

Uganda.—Gulf Industrials Ltd. (Sidney, Australia) continued development of and production at the East African Namekara vermiculite deposit, as part of the company's larger East African Vermiculite Project (EAVP) in eastern Uganda. The EAVP, considered to be one of the world's largest deposits, has about 55 Mt of inferred resources, including significant quantities of coarse grades of vermiculite. The company planned to increase production capacity from 4,000 t/yr of raw vermiculite concentrate in 2010 to 18,000 t/yr with the installation of a new drier system in 2011 and to 80,000 t/yr during 2012 (Elliott, 2011b). The Namekara deposit has sufficient resources for more than 50 years at planned rates of production. The company secured a 25-year sales contract for all production with Dupres Minerals Ltd., which will market and distribute the product (Proactive Investors Australia, 2010; Gulf Industrials Ltd., 2011, p. 2–4).

Outlook

With increased demand globally and a tightening of supply, especially in coarser grades, prices were expected to rise, possibly significantly, in 2011. Vermiculite production was expected to continue to increase worldwide in 2011 reflecting a continued slow recovery from the global economic recession. The ramping up of production from major mining operations in Brazil and Uganda was expected to contribute to increased production in 2012. The Imerys Xinlong Mine in China was expected to reopen in late 2011 or early 2012.

International Monetary Fund (IMF) forecasts of global economic growth for 2011 and 2012 were mostly unchanged from those completed in early 2010. The world economy was expected to grow at about 4.5% per year in each year, with offsetting changes across various economies—advanced economies increasing at about 2.5% and emerging and developing economies at about 6.5%. Growth in the global economy may result in increased activity in vermiculite markets in 2011–12. Because of anticipated increases in construction activity and a continued recovery from the global economic recession, North American vermiculite markets could increase

2% to 3%, while those in Europe and Asia may increase by % and 5% or more, respectively (International Monetary Fund, 11).

Owing to the energy-intensive process associated with the foliation of vermiculite in traditional blast furnaces, natural ıs prices typically dictate price fluctuations for exfoliated rmiculite. Prices, which remained stable in 2009, rose slightly 2010. In the event of increased natural gas prices, the cost for foliated vermiculite would probably increase likewise.

new microwave technology under development held promise significantly reduce the energy needed for processing crude rmiculite, and, by producing a more consistent heating rocess on all the vermiculite flakes, to increase the proportion at is exfoliated successfully. Up to 8% of vermiculite is not lly exfoliated in traditional blast furnace processing; that ortion is difficult to utilize in end products and incurs costs for aste disposal (Elliott, 2011a).

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TABLE 1
SALIENT VERMICULITE STATISTICS[1]

(Thousand metric tons and thousand dollars unless otherwise specified)

		2006	2007	2008	2009	2010
United States:						
Production, concentrate[e, 2, 3]		100	100	100	100	100
Exfoliated:[e]						
Quantity		90	85	82	69	73
Value[e]		36,500	36,500	40,100	33,600	41,200
Average value[e, 4]	dollars per metric ton	406	429	489	487	564
Exports[e]		5	5	5	3	2
Imports for consumption[5]		65 [e]	51	73	39	29
World, production		512 [r]	510 [r]	525 [r]	509 [r]	536 [e]

[e]Estimated. [r]Revised.

[1] Data are rounded to no more than three significant digits unless otherwise specified.

[2] Sold or used by producers.

[3] Rounded to the nearest 100,000 metric tons to avoid disclosing company proprietary data.

[4] Based on rounded data.

[5] Source: United Business Media Global Trade, a division of United Business Media Ltd., 2010.

TABLE 2
ACTIVE VERMICULITE EXFOLIATION PLANTS IN THE UNITED STATES IN 2010

Company	County	State
Isolatek International Inc.	Sussex	New Jersey.
J.P. Austin Associates Inc.	Beaver	Pennsylvania.
Palmetto Vermiculite Co. Inc.	Spartanburg	South Carolina.
P.V.P. Industries, Inc.	Trumbull	Ohio.
Schundler Co., The	Middlesex	New Jersey.
Southwest Vermiculite Co., Inc.	Bernalillo	New Mexico.
Sun Gro Horticulture Canada Ltd.	Jefferson	Arkansas.
Do.	LaSalle	Illinois.
Thermal Ceramics Inc.	Macoupin	Do.
Therm-O-Rock East, Inc.	Washington	Pennsylvania.
Therm-O-Rock West, Inc.	Maricopa	Arizona.
Verlite Co.	Hillsborough	Florida.
Vermiculite Industrial Corp.	Allegheny	Pennsylvania.
Whittemore Co., Inc.	Essex	Massachusetts.
W.R. Grace & Co.	Maricopa	Arizona.
Do.	Broward	Florida.
Do.	Laurens	South Carolina.

Do. Ditto.

TABLE 3
ESTIMATED EXFOLIATED VERMICULITE SOLD OR USED IN THE UNITED STATES, BY END USE[1]

(Metric tons)

	2009	2010
Aggregates[2]	24,300	14,300
Insulation[3]	5,860	5,560
Agricultural:		
Horticultural	14,900	17,400
Soil conditioning	W	11,000
Fertilizer carrier	W	W
Total	W	W
Other[4]	W	W
Grand total[5]	69,000	73,000

W Withheld to avoid disclosing company proprietary data; included in "Grand total."

[1] Data rounded to no more than three significant digits; may not add to totals shown.

[2] Includes concrete, plaster, and premixes (acoustic insulation, fireproofing, and texturizing uses).

[3] Includes loose-fill, block, and other (high-temperature and packing insulation and sealants).

[4] Includes various industrial and other uses not specified.

[5] Rounded to two significant digits because of estimated data.

TABLE 4
VERMICULITE: WORLD PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country	2006	2007	2008	2009	2010[e]
Argentina	1,585	1,726	1,813	2,150 [r]	2,000
Australia[e]	13,000	13,000	13,000	12,000	13,000
Brazil, concentrate	19,279	18,952	20,089	20,100	35,000
Bulgaria	--	--	--	--	3,000
China[e]	110,000	110,000	120,000	120,000	120,000
Egypt[e]	12,000	5,770 [3]	7,560 [3]	12,000 [r]	12,000
India	10,539 [r]	9,639 [r]	11,742 [r]	12,000 [r, e]	13,000
Japan[e]	6,000	6,000	6,000	6,000	6,000
Russia[e]	25,000	25,000	25,000	25,000	25,000
South Africa	197,765	198,526	199,764	193,334	198,005 [3]
Uganda[e]	3,512 [3]	3,500	3,500	3,600	3,500
United States, concentrate, sold and used by producers[e, 4]	100,000	100,000	100,000	100,000	100,000
Zimbabwe	13,421 [r]	17,395 [r]	16,123 [r]	3,211 [r]	5,000
Total	512,000 [r]	510,000 [r]	525,000 [r]	509,000 [r]	536,000

[e] Estimated. [r] Revised. -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Excludes production by countries for which data are not available and for which general information is inadequate for formulation of reliable estimates. Table includes data available through July 13, 2011.

[3] Reported figure.

[4] Rounded to avoid disclosing company proprietary data.

WOLLASTONITE

By Robert L. Virta

Domestic survey data were prepared by Hodan A. Fatah, statistical assistant.

Wollastonite was mined by two companies in the United States in 2010. U.S. production data collected by the U.S. Geological Survey (USGS) are withheld to avoid disclosing company proprietary data, but U.S. production and sales increased with the recovery of the global economy from the 2008–09 recession. Exports of wollastonite were estimated to be less than 10,000 metric tons (t), but greater than those of 2009. Imports of wollastonite were estimated to be less than 4,000 t in 2010, unchanged from those of 2009. World sales of refined wollastonite products were estimated to be in the range of 460,000 to 500,000 t in 2010 compared with 430,000 to 470,000 t in 2009.

Wollastonite, a calcium metasilicate ($CaSiO_3$), has an ideal composition of 51.7% silicon dioxide and 48.3% calcium oxide but can also contain trace to minor amounts of aluminum, iron, magnesium, manganese, potassium, sodium or strontium substituting for calcium. Wollastonite occurs in the form of prismatic crystals that break into tabular-to-acicular fragments. It is usually white but also may be gray, cream, brown, pale-green, or red depending on the impurities and grain size. Wollastonite is used primarily in automobile brakes, ceramics, metallurgical processing, paint, and plastics. Some of the properties that make it so useful are high brightness and whiteness, low moisture and oil absorption, low volatile content, and the acicular nature of some wollastonite.

Production

In 2010, domestic wollastonite production increased from that of 2009. Data collected by the USGS are withheld to avoid disclosing proprietary information. Average annual U.S. wollastonite production was reported in the trade literature to be about 65,000 tons per year (t/yr) in 2009 (Ellen, 2009; Feytis, 2009).

Wollastonite has been mined commercially in California and New York. The California deposits, which are in Inyo, Kern, and Riverside Counties, were mined between 1930 and 1970. These operations were limited in size, producing only a few thousand metric tons each year for ceramics, decorative stone, paint, and mineral wool production before closing.

Wollastonite deposits in New York have been mined for more than 50 years. Two companies mined wollastonite in 2010—NYCO Minerals, Inc. [a subsidiary of Resource Capital Fund IV L.P. (RCF), Denver, CO], which operated a mine in Essex County, and R.T. Vanderbilt Co., Inc., through its Gouverneur Mineral Division, which operated a mine in Lewis County. The NYCO deposit contains diopside, garnet, and wollastonite. Parts of the deposit contain up to 60% wollastonite. The ore was processed at the Willsboro, NY, plant, where the garnet was removed using high-intensity magnetic separators. NYCO also chemically modified the surfaces of some of its wollastonite products to improve their performance. R.T. Vanderbilt's deposit consists primarily of wollastonite with minor amounts of calcite and prehnite and trace amounts of diopside. The ore was processed at the company's St. Lawrence County plant, where it was milled and air classified. R.T. Vanderbilt also produced surface-treated products.

Consumption

The USGS does not collect end-use data on wollastonite. Based on company press releases, general overview articles, U.S. manufacturing trends, and previously published consumption estimates, plastics and rubber applications were estimated to account for 30% to 35% of U.S. sales in 2010, followed by ceramics with 20% to 25%; metallurgical applications, 10% to 20%; paint, 10% to 15%; friction products, 10% to 15%; and miscellaneous, 10% to 15%.

Ceramic applications probably account for 30% to 40% of wollastonite sales worldwide, followed by polymers (plastics and rubber) with 30% to 35% of sales, and paint with 10% to 15% of sales. The remaining sales were for construction, friction products, and metallurgical applications (Kendall, 2001; Robinson, 2006).

The distribution of sales among domestic markets may have shifted slightly towards plastics and metallurgical applications in 2010 compared with those of 2009 because automobile manufacturing and steel demand began to recover from the global recession earlier than other wollastonite markets. Commercial and residential construction activity, where wollastonite may be used in products such as adhesives, caulks, ceramics, paints, stucco, and roof coatings, did not increase significantly from levels in 2009. The trend in wollastonite sales in Europe in 2010 probably was similar to that in the United States. In Asia, growth was likely more uniform across all markets.

In ceramics, wollastonite decreases shrinkage and gas evolution during firing, increases green and fired strength, maintains brightness during firing, permits fast firing, and reduces crazing, cracking, and glaze defects. In metallurgical applications, wollastonite serves as a flux for welding, a source for calcium oxide, a slag conditioner, and to protect the surface of molten metal during the continuous casting of steel. As an additive in paint, it improves the durability of the paint film, acts as a pH buffer, improves its resistance to weathering, reduces gloss, reduces pigment consumption, and acts as a flatting and suspending agent. In plastics, wollastonite improves tensile and flexural strength, reduces resin consumption, and improves thermal and dimensional stability at elevated temperatures. Surface treatments are used to improve the adhesion between the wollastonite and the polymers to which it is added. As a substitute for asbestos in floor tiles, friction products, insulating board and panels, paint, plastics, and roofing products, wollastonite is resistant to chemical attack, inert, stable at high temperatures, and improves flexural and tensile strength (Roskill Information Services Ltd., 1996, p. 58–59, 78–81, 104–107, 119, 123–128).

Prices

Quoted prices for domestically produced acicular wollastonite, ex-works, were $200 to $230 per metric ton for 200-mesh, $210 to $240 per ton for 325-mesh, and $444 for high-aspect-ratio wollastonite. Prices for wollastonite from China, free on board, in bulk, were $80 to $90 per ton for 200-mesh and $90 to $100 per ton for 325-mesh (Industrial Minerals, 2010). Hawley (2010) indicated that wollastonite sold for plastics applications was $600 to $1,800 per ton, and prices for ceramic grades of wollastonite were $200 to $450 per ton from a major U.S. producer. Quoted prices should be used only as a guideline because actual prices depend on the terms of the contract between the seller and the buyer.

Foreign Trade

Comprehensive trade data were not available for wollastonite because it is included under generic U.S. Census Bureau Harmonized Tariff Schedule (HTS) code 2530.90.8060 (mineral substances not elsewhere specified or included). Some wollastonite also may be exported under HTS code 2121.00.0000 (limestone flux; limestone and other calcareous stone). With the global economy showing signs of recovery from the 2008–09 economic recession, U.S. exports were likely to have increased from those of 2009. Documented exports were in the range of 1,500 to 2,000 t. These exports were moved by ship to Argentina, Australia, Belgium, Brazil, China, Colombia, the Dominican Republic, Germany, Hong Kong, India, Japan, the Netherlands, Nicaragua, the Republic of Korea, South Africa, and the United Kingdom (United Business Media Global Trade, undated). Additional quantities probably were transported by truck or train to Canada.

U.S. imports were estimated to be less than 4,000 t in 2010, about the same as in 2009. Imports transported by ship were received from China, Finland, Germany, and India. India was reported to be the leading source of wollastonite imported into the United States by ship, followed by Finland, China, and Germany (United Business Media Global Trade, undated). Imports from Germany were thought to be transshipments because there is no mining of wollastonite in Germany. Small additional quantities of wollastonite may have been imported by rail or truck from Canada and Mexico.

World Review

World production of crude wollastonite ore probably increased by 5% to 10% in 2010 compared with that of 2009 as many countries began to recover from the recent global recession, and the Asian economy continued to remain strong. Estimated crude ore production increased and was in the range of 550,000 to 575,000 t in 2010 compared with 520,000 to 540,000 t in 2009. Sales of refined wollastonite products probably were in the range of 460,000 to 500,000 t in 2010, an increase from 430,000 to 470,000 t in 2009.

In 2010, wollastonite production in China was estimated to be 300,000 to 320,000 t (300,000 t in 2009), and production in India was probably 145,000 t (132,000 t in 2009). The United States ranked third in wollastonite production (about 65,000 t in 2009). Production in Mexico was estimated to have increased to 40,000 t in 2010 (29,700 t in 2009). Following Mexico in ranking were Finland (16,000 t in 2009), Spain (7,000 t in 2009), and Namibia (55 t in 2009) (Brown and others, 2011, p. 103). Small quantities of wollastonite may have been produced in other countries. Data for 2010 were not available for most countries.

Finland.—Rettig Group acquired full ownership of Nordkalk Corp., which produced limestone and wollastonite. Rettig became a shareholder of Nordkalk in 2002 and gradually increased its holdings over time. Nordkalk was one of the top five world wollastonite producers (Feytis, 2010a).

India.—Wolkem India Ltd. increased production capacity at its mine in the Sirohi district of Rajasthan by 15% to 175,000 t/yr (Feytis, 2011).

South Africa.—Namaqua Wollastonite (Pty.) Ltd. announced plans to begin wollastonite mining at its Magata project near Garies, Namaqualand. The wollastonite had a high aspect ratio but also had a high iron content. Namaqua planned to market their wollastonite as an asbestos substitute and for construction applications, friction products, and plastics (Feytis, 2010b).

Outlook

Demand for and production of wollastonite increased in 2010 as countries began to slowly recover from the global recession. U.S. manufacturing began to increase in 2010, resulting in increased demand for wollastonite for such applications as powder coatings for consumer appliances, surface conditioners for steel casting, ingredients for manufacturing technical ceramic bodies, and reinforcements for plastics products. Commercial and residential construction remained almost unchanged in 2010. Consequently, demand for wollastonite for architectural paints, caulks, ceramic tile glazes and bodies, roof coatings, sanitaryware, sealants, stucco, and wallboard did not increase significantly. Use of wollastonite in structural clay products, such as brick and quarry tile, also did not increase significantly because of the continued slow construction markets. The automotive industry increased its output in 2010, increasing demand for wollastonite for the manufacture of such items as friction products and wollastonite-reinforced plastic automotive components.

Economic growth was expected to be greatest in countries with developing and emerging economies, where the average economic growth rate was expected to be 6.5% in 2011 and 2012. For countries with advanced economies, the average growth rate was expected to be 2.5% in 2011 and 2012 (International Monetary Fund, 2011). The slower growth in countries with advanced economies probably will prompt European and North American wollastonite producers to continue to direct their marketing attention towards Asian markets.

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ZEOLITES

By Robert L. Virta

Domestic survey data and table were prepared by Hodan A. Fatah, statistical assistant.

In 2010, natural zeolites were mined by 10 companies in the United States, with one other company working from stockpiled materials or zeolites purchased from other producers for resale. Mine production was 61,300 metric tons (t) in 2010 compared with 59,500 t in 2009, and U.S. consumption was 60,000 t in 2010 compared with 59,400 t in 2009. The major markets were in animal feed, pet litter, odor control, and water purification, in decreasing order by tonnage. These four applications accounted for more than 70% of domestic consumption. Exports of natural zeolites (other than gem quality) were estimated to be less than 400 t, and imports were estimated to be less than 150 t. World production was estimated to be in the range of 2.8 million to 3.3 million metric tons (Mt).

Commercial zeolite deposits in the United States are associated with the alteration of volcanic tuffs in alkaline lake deposits and open hydrologic systems. In the United States, these deposits are in Arizona, California, Idaho, Nevada, New Mexico, Oregon, Texas, and Wyoming. Zeolites in these deposits are chabazite, clinoptilolite, erionite, mordenite, and phillipsite. Other components, such as orthoclase and plagioclase feldspars, montmorillonite, opal, quartz, and volcanic glass, are present in some deposits.

Legislation and Government Programs

The U.S. Environmental Protection Agency, the North Dakota Department of Health, and the University of Cincinnati conducted a health study of 34 individuals to determine if breathing dust containing erionite could cause adverse health effects. Health scientists were concerned because erionite was classified as a human carcinogen by the International Agency for Research on Cancer, exposure to erionite might be linked to excess cancers in several villages in Turkey, and erionite was present in gravels that had been used for decades on roads in North Dakota (International Agency for Research against Cancer, 1998; U.S. Environmental Protection Agency Region 8 and North Dakota Department of Health, 2010, p. 5–9). The study results suggested that workers involved in road maintenance or gravel pits that were exposed to road gravel containing erionite could develop changes in the membranes surrounding the lungs (pleural changes) that historically are associated with exposure to asbestos, and that precautionary measures should be followed concerning such workers (U.S. Environmental Protection Agency Region 8 and North Dakota Department of Health, 2010, p. 5–9, 28–30).

In connection with the health study, the chemical and morphological characteristics of erionite from gravel deposits near Killdear Mountain, ND, were compared with those of erionite from Rome, OR, and the Cappadocia region of Turkey. All samples contained erionite fibers and fiber bundles with dimensions of 0.2 to 10 micrometers (µm) in diameter and 2 µm to more than 200 µm in length. Airborne erionite fibers from Turkey had higher length-to-width ratios than those from North Dakota. The chemical characteristics of samples from all three locations were similar, and the calculated structural formulae were similar to those of erionite (Lowers and others, 2010).

Production

Domestic data for natural zeolites were collected by means of a voluntary survey of the domestic mining industry. Survey forms were sent to 11 companies, and 10 responded. Responses accounted for more than 99% of the production and end-use data.

Conventional open pit mining techniques are used to mine natural zeolites. The overburden is removed to allow access to the ore. The ore may be blasted or stripped for processing by using front-end loaders or tractors equipped with ripper blades. In processing, the ore is crushed, dried, and milled. The milled ore may be air-classified based on particle size and shipped in bags or bulk. The crushed product may be screened to remove fine material when a granular product is required, and some pelletized products are produced from fine material. Producers also may modify the properties of the zeolite or blend their zeolite products with other materials before sale to enhance their performance.

Ten companies mined natural zeolites in the United States in 2010. One company did not mine zeolites during the year but sold from stocks or purchased zeolites from other producers for resale (table 1). Chabazite was mined in Arizona; clinoptilolite was mined in California, Idaho, Nevada, New Mexico, and Texas. Domestic production of zeolites was 61,300 t compared with 59,500 t of production in 2009. New Mexico was the leading producing State in 2010, followed by Idaho, Texas, Arizona, California, and Nevada.

Bear River Zeolite Co., Inc. (a subsidiary of United States Antimony Corp.) reported that sales revenue increased by 57% to $2.42 million in 2010 compared with $1.54 million in 2009. The company shipped 15,300 t of zeolites in 2010 compared with 11,500 t in 2009 (United States Antimony Corp., 2011, p. 21).

Daleco Resources Corp. continued evaluating its clinoptilolite deposit near Marfa, TX. In addition to test samples, Daleco also sold 120 t of unprocessed zeolite for animal feed supplement, wastewater treatment, and miscellaneous uses (Daleco Resources Corp., 2011, p. 9).

Consumption

About 60,000 t of natural zeolites was sold in 2010 in the United States compared with 59,400 t in 2009. Domestic uses for natural zeolites were, in decreasing order by tonnage, animal feed, pet litter, odor control, water purification, gas absorbent (and air filtration), wastewater cleanup, fertilizer, desiccant, oil absorbent, aquaculture, fungicide or pesticide carrier, and catalyst. Animal feed, odor control, pet litter, and water purification applications accounted for more than 70% of the domestic sales tonnage.

Increased sales of natural zeolites were reported for aquaculture, catalyst, desiccant, gas absorbent, pet litter, soil amendments, and water purification. The largest tonnage increases in sales were for odor control and pet litter applications. Sales for nuclear waste cleanup increased significantly because of a remediation project at a former nuclear fuel reprocessing facility in West Valley, NY. Bear River Zeolite reported that it provided almost 2,000 t of zeolite for the project. The zeolite was placed in a trench to contain strontium-90 (a radioactive isotope of strontium that is a byproduct of nuclear reactions) in groundwater that was migrating away from the former nuclear processing site. The purpose of the zeolites was to filter out the strontium-90 while allowing groundwater to pass through the trench wall (O'Driscoll, 2010; Bear River Zeolite Co., Inc., 2011).

Sales of natural zeolites declined for animal feed, fertilizer, fungicide and pesticide carriers, odor control, oil absorbent, and wastewater treatment applications. The largest tonnage decline was in animal feed use.

Prices

Prices for natural zeolites vary with zeolite content and processing. Unit values, obtained through the U.S. Geological Survey canvass of domestic zeolite producers, ranged from $40 to $900 per metric ton. The bulk of the tonnage sold was between $99 and $170 per ton, which was typical of large, bulk shipments. Eyde (2010) reported that the average price for clinoptilolite granules was about $145 per ton and that modified clinoptilolite and activated chabazite products sold for as much as $8 per kilogram. For such products as fish tank media, odor control, or pet litter applications, prices ranged from $0.50 to $4.50 per kilogram. Quoted prices should be used only as a guideline because actual prices depend on the terms of the contract between seller and buyer.

Foreign Trade

Comprehensive trade data were not available for natural zeolites. In 2010, exports of natural zeolites (other than gem-quality specimens) were estimated to be less than 400 t, and imports were estimated to be less than 150 t. The bulk of the U.S. zeolite trade was in synthetic zeolite products.

World Review

World production of natural zeolites was in the range of 2.8 to 3.3 Mt in 2010 based on reported production by some countries, world market trends, and production estimates published in trade journals. World production probably declined slightly in 2010 because sales to pozzolanic cement markets were likely to have been affected by the recent recession.

Natural zeolite production data were not available for most countries. Countries mining large tonnages of zeolites typically use them in low-value applications. The ready availability of zeolite-rich rock at low cost and the shortage of competing minerals and rocks were probably the most important factors for its large-scale use. It was also likely that a significant percentage of the material sold as zeolites in some countries was ground or sawn volcanic tuff that contained only a small amount of zeolites. Some examples of such usage are dimension stone (as an altered volcanic tuff), lightweight aggregate, pozzolanic cement, and soil conditioners.

Estimates for individual countries were: China (including pozzolanic cement applications), 1.7 to 2.2 Mt; Jordan (nearly all for pozzolanic applications), 380,000 to 430,000 t; the Republic of Korea, 235,000 t; Turkey, 150,000 t (excluding pozzolanic cement applications); Japan (including pozzolanic cement applications), 130,000 to 150,000 t; Slovakia, 80,000 t; the United States, 61,300 t; Cuba, 27,000 t; Hungary, 20,000 to 25,000 t; Ukraine (including pozzolanic cement applications), 15,000 to 35,000 t; New Zealand, 22,000 t; Bulgaria (excluding pozzolanic cement applications), 17,000 t; South Africa, 10,000 to 15,000 t; Australia, Russia, and Spain, 5,000 to 10,000 t each; Canada, Greece, Italy, and the Philippines, 3,000 to 5,000 t each; Mexico, 1,000 t; and Indonesia (excluding pozzolanic cement applications), 400 to 500 t. Small amounts of natural zeolites (probably less than 1,000 to 2,000 t) also were produced in Argentina, Armenia, Georgia, Germany (excluding pozzolanic cement applications), Serbia, and Slovenia.

Outlook

U.S. production and sales of natural zeolites increased slightly in 2010 from those of 2009. The annual rate of increase in U.S. consumption of natural zeolites was lower between 2006 and 2010 than in most of the prior 20 years, but it still increased slightly each year. Annual growth of 1% to 3% is likely to continue for the next 3 to 4 years. Any large changes in domestic consumption that may take place during this time would likely be the result of one or two special projects that have limited life spans, such as the West Valley remediation project discussed in the Consumption section above.

World demand continued to be affected by the global economic recession because sales in many countries were linked to construction activities, where natural zeolites and (or) zeolitic tuffs were sold were dimension stone, lightweight aggregate, and pozzolanic cement. Although the economies of many nations were recovering in 2010, world consumption was likely to remain unchanged through 2013.

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TABLE 1

DOMESTIC ZEOLITE PRODUCERS IN 2010[1]

State and company	Type of zeolite
Arizona:	
GSA Resources, Inc.	Chabazite.
UOP LLC	Do.
California:	
Ash Meadows, LLC	Clinoptilolite.
KMI Zeolite Inc.	Do.
Idaho:	
Bear River Zeolite Co., Inc. (United States Antimony Corp.)	Do.
Steelhead Specialty Minerals, Inc.	Do.
Teague Mineral Products Co.	Do.
Nevada, Moltan Co., L.P.	Do.
New Mexico, St. Cloud Mining, Inc.	Do.
Texas, Zeotech Corp.	Do.

Do. Ditto.

[1] Addwest Minerals International Ltd. worked from stocks or purchased zeolites from other producers for resale.

ZINC

By Amy C. Tolcin

Domestic survey data and tables were prepared by Hodan A. Fatah, statistical assistant, and the world production tables were prepared by Lisa A. Miller, international data coordinator.

In 2010, U.S. production of recoverable zinc was 723,000 metric tons (t), a slight increase from that of 2009 (table 1). The value of domestic mine production was approximately $1.62 billion. Alaska continued to be the dominant zinc-producing State, accounting for 87% of recoverable production. Zinc was also produced from mines in Idaho, Missouri, and Tennessee. Domestic exports of zinc contained in ores and concentrate decreased by 4% to 752,000 t in 2010 and were predominantly sent to Canada (19%), Japan (18%), the Republic of Korea (17%), and Spain (15%) (table 7). Imports for consumption of zinc contained in ores and concentrates decreased by 57% to 32,200 t from those in 2009. Total U.S. refined zinc production in 2010 was estimated to have increased by 22% to 249,000 t. Imports of refined zinc in 2010 decreased slightly to 671,000 t. Refined zinc was imported primarily from Canada (75%), Mexico (12%), Spain (6%), and Peru (4%). Domestic exports of refined zinc increased by 1,240 t to 4,200 t in 2010. Globally, zinc mine production increased by 6% to 12 million metric tons (Mt); zinc metal production increased by 13% to 12.7 Mt (tables 10, 11).

Legislative and Government Programs

A U.S. stockpile of zinc has been maintained since 1967 for national defense purposes. In 1992, Public Law 102–484, which authorized the disposal of the entire inventory of zinc from the National Defense Stockpile (NDS), was signed. The Defense Logistics Agency, DLA Strategic Materials (formerly Defense National Stockpile Center), which maintains the NDS, was authorized to sell 7,710 t of zinc during fiscal year 2010 (October 1, 2009, to September 30, 2010; actual quantity sold would be limited to remaining inventory). However, there were no sales of zinc during the fiscal year; sales of zinc from the NDS have been suspended since August 2008 owing to concerns regarding domestic availability and access to various raw materials. The Department of Defense (DOD) submitted an initial report to Congress in August 2006, which recommended a more detailed review of the current stockpile disposal policy and to determine whether the NDS could assure future availability of materials for defense needs considering current world market conditions. In August, the Secretary of Defense submitted a report outlining several strategies the DOD can undertake to mitigate possible disruptions to material supplies, including strategic sourcing, partnerships with foreign nations, and traditional stockpiling (U.S. Department of Defense, 2009, p. 8, 58; 2011, p. 2, 6).

Environment and Health

Zinc is an important micronutrient for human health by helping to maintain proper enzyme activity. Diarrhea, caused by contaminated drinking water and poor sanitation, causes the death of approximately 1.5 million children per year and is the second leading cause of death among children under five. Zinc supplements, in conjunction with oral rehydration salts, have been recommended for the treatment of acute diarrhea by the World Health Organization since 2004. In 2009, the Clinton Global Initiative, the International Zinc Association, and UNICEF partnered together to create the "Zinc Saves Kids" program in an effort to eliminate zinc deficiency in developing countries. Since the creation of the initiative, about 50 countries have adopted new policies to include zinc supplementation in child health management.

The "HarvestZinc Fertilizer Project" was developed in 2008 under the support of several fertilizer and zinc associations to test the use of zinc fertilizers on rice and wheat crops to increase crop yield and correct zinc-deficient soils. The initial phase of the project, which included identifying the zinc fertilizers and application times that would lead to the greatest zinc accumulation in grain, was to be completed in 2011.

Production

Mine.—In 2010, zinc was produced in four States, with Alaska as the leading zinc-producing State. Other zinc-producing States were Idaho, Missouri, and Tennessee. Domestic mine production of recoverable zinc in 2010 was 723,000 t, a slight increase from that of 2009. A decrease in production in Alaska was offset by an increase in Tennessee, owing to the continued ramp up at Nyrstar NV's (Balen, Belgium) East Tennessee and Middle Tennessee zinc mining complexes. Domestic mine production data were collected by the U.S. Geological Survey (USGS) from a base-metal voluntary survey of lode-mine production. Four companies responded monthly, accounting for 100% of U.S. zinc mine production.

Alaska.—Teck Alaska Inc. (a subsidiary of Teck Resources Ltd., Vancouver, British Columbia, Canada) operated the open pit Red Dog zinc-lead mine in the Northwest Arctic Borough under a royalty agreement with NANA Regional Corporation Inc., an Alaskan Native-owned corporation.

Zinc in concentrate production at Red Dog decreased by 8% in 2010 from that of 2009 to 538,000 t owing to lower mill feed grades. In 2010, approximately 28% of Red Dog's zinc concentrates were refined at Teck's metallurgical complex at Trail, British Columbia, Canada. Remaining concentrates were sent to Asia and Europe. Reported ore reserves at yearend 2010 totaled 55.3 Mt averaging 15.9% zinc. Zinc in concentrate production in 2011 was projected to total 555,000 t (Teck Resources Ltd., 2011a, p. 34; b, p. 23, 31).

In January, Teck received the necessary permitting from the U.S. Environmental Protection Agency to develop the Aqqaluk Deposit at Red Dog. Pit development commenced in May, and the first ore from the deposit was processed in August. Teck's operating plan was to continue mining the Main Pit until mid-2011. During this time, the ore will be supplemented with ore from Aqqaluk to maintain efficient production rates (Teck Resources Ltd., 2011b, p. 22–23).

Hecla Mining Co.'s (Coeur d'Alene, ID) underground Greens Creek Mine is a polymetallic (silver-zinc-gold-lead) massive sulfide deposit located on Admiralty Island in the Tongass National Forest near Juneau. Products included gold and silver dore, as well as lead and zinc concentrates, which were sold to smelters globally. In 2010, zinc in concentrate production increased by 6% from that of 2009 to 67,600 t. Reserves at yearend were 7.48 Mt grading 9.3% zinc (Hecla Mining Co., 2011a, p. 12).

Historically, Greens Creek was completely powered by diesel generators located onsite. In 2006, necessary infrastructure was completed to allow surplus hydroelectric power supplied by Alaska Electric Light and Power Co. to reach Greens Creek's facilities. During 2009 and 2010, the mine sourced an increasing amount of its power from hydroelectricity. The project reduced Greens Creek's production costs, which were significantly affected by diesel fuel prices in the past few years (Hecla Mining Co., 2011b, p. 12).

Idaho.—Hecla Mining operated the Lucky Friday Mine, an underground silver-lead-zinc mine in the Coeur d'Alene Mining District in northern Idaho. Products included silver-lead concentrate and zinc concentrate. All concentrates in 2010 were sent to Teck's facility at Trail for processing. Zinc in concentrate production at Lucky Friday decreased by 13% in 2010 from that of 2009 to 8,420 t. At yearend, reserves measured 2.89 Mt grading 2.9% zinc (Hecla Mining Co., 2011b, p. 16).

During 2010, Hecla Mining continued early-stage development of an internal shaft ("#4 Shaft") that would provide access to ore-grade mineralization deeper than the current mining level and extend Lucky Friday's mine life. The company expected full project approval in mid-2011. Production levels at Lucky Friday may be affected as development for the new shaft would take place in the current production shaft ("Silver Shaft") (Hecla Mining Co., 2011a, p. 7).

Missouri.—Doe Run Resources Corp. (St. Louis, MO) operated a series of production shafts that run along the Viburnum Trend lead-zinc-copper ore body in southeast Missouri. Doe Run processed the ore at four mills to produce primarily lead concentrates and to a lesser extent, zinc and copper concentrates.

Tennessee.—In 2009, Nyrstar acquired the Middle Tennessee zinc mine complex from Strategic Resource Acquisition Corp. (Toronto, Ontario, Canada) and the East Tennessee zinc mine complex from Glencore International AG (Baar, Switzerland). The mine acquisitions were part of Nyrstar's strategy to increase its vertical integration with the intention of sourcing 50% of its raw material needs internally. The East Tennessee mine complex (the Coy, Immel, and Young Mines) produced 50,000 t of zinc in concentrate in 2010 and was operating at full capacity by the third quarter. The Middle Tennessee mine complex (the Cumberland, Elmwood, and Gordonsville Mines) produced 13,000 t of zinc in concentrate during the year and was operating at 35% of production capacity by yearend. Nyrstar expected the mines to reach full production capacity [130,000 metric tons per year (t/yr) of zinc in concentrate for both complexes] in early 2011. The concentrate from the Tennessee mines would provide 100% of the feedstock requirements at Nyrstar's Clarksville, TN, zinc refinery. Reserves for the Tennessee mines totaled 5.1 Mt at 3.3% zinc (Nyrstar NV, 2011a, p. 22; b, p. 13).

Smelter.—Domestic metal production data were collected by the USGS from a voluntary survey of zinc metal and compounds production. Domestic zinc metal production data were partially estimated based on publicly available information to protect company proprietary data. In 2010, refined zinc was mainly produced in two States—Pennsylvania (Horsehead Holding Corp.'s Monaca facility) and Tennessee (Nyrstar's Clarksville facility). Refined zinc was also produced to a lesser extent by U.S. Zinc's (owned by Votarantim Metais, Sao Paulo, Brazil) recycling operations in Coldwater, MI, and Houston, TX. Estimated refined zinc production in 2010 was 249,000 t.

Primary.—Nyrstar's Clarksville electrolytic zinc refinery was the only primary zinc smelter in the United States. Products included Special High Grade (SHG) zinc metal and galvanizing alloys as well as a number of byproducts including cadmium metal, intermediate copper cementate, leach product, synthetic gypsum, and sulfuric acid. Refined zinc production in 2010 increased by 28% from that of 2009 to 120,000 t. The smelter operated at full production capacity the entire year compared with production in 2009 when the smelter operated at reduced levels in the first half of the year in response to the downturn in the zinc market. The zinc recovery rate also improved owing to the inclusion of the Tennessee mines' concentrates, which are a higher grade of zinc compared with other concentrates that have been treated by the refinery in the past (Nyrstar NV, 2011b, p. 14–15).

Secondary.—Horsehead produced zinc metal—primarily Prime Western Grade (PW) and to a lesser extent, Special Special High Grade (SSHG)—and zinc oxide at its electrothermic zinc smelter (159,000 t/yr capacity) in Monaca. The PW zinc was sold to hot-dip galvanizers and brass manufacturers, and the SSHG zinc was used as feed for the production of high-purity zinc alloys and powder. Feedstock for the metal production was composed entirely of secondary materials; 73% of the feedstock was sourced from Horsehead's electric arc furnace (EAF) dust recycling operations, and the balance was composed of dross and skimmings sourced from hot-dip galvanizers. Other zinc-bearing residues were sourced from the alloying, brass, and zinc industries. EAF dust is a waste product recovered from the air flow exiting electric arc furnaces during the steel recycling process and typically contains 10% to 20% zinc (Horsehead Holding Corp., 2011a, p. 9).

In addition to the Monaca facility, Horsehead operated six other facilities, including five EAF dust recycling operations located in Barnwell, SC; Beaumont, TX; Calumet, IL; Palmerton, PA; and Rockwood, TN, and a hydrometallurgical metals recovery facility in Bartlesville, OK. In 2010, Horsehead brought the Barnwell, SC, dust recycling facility into production. The new facility has the capacity to process 163,000 t/yr of EAF dust, increasing the company's total EAF dust processing capacity by 31% to 699,000 t/yr (Horsehead Holding Corp., 2011a, p. 8, 25).

In 2010, Horsehead recycled 498,000 t of EAF dust compared with 373,000 t in 2009. The company attributed the processing rate increase to its acquisition of additional EAF dust sourcing contracts and an increase in domestic steel production. Zinc production at Monaca totaled 112,000 t, a 17% increase from production in 2009 (Horsehead Holding Corp., 2011a, p. 8; b).

Small quantities of secondary refined zinc were also produced at U.S. Zinc's operations in Coldwater and Houston. The facilities produced PW grade and continuous galvanizing grade zinc metal primarily from galvanizing residues, such as dross and skimmings.

Consumption

Reported U.S. zinc consumption in 2010 was 358,000 t, representing 39% of domestic apparent consumption. Domestic apparent consumption of zinc in 2010 was 907,000 t, a slight increase from apparent consumption in 2009. Reported slab zinc consumption data were collected by the USGS from a voluntary survey on zinc consumption by grade and end use. Changes in zinc consumption usually follow trends in industrial production or, more generally, global economic growth. Global economic activity expanded during 2010, albeit at a sluggish pace. The rate of economic growth in the United States and Japan was slower than that of Europe and the major emerging economies—most notably Brazil, China, and India. The principal use for zinc is for galvanizing, in which a zinc coating is applied to steel to prevent corrosion. Galvanized steel is used extensively in the automotive industry (for example, the vehicle autobody) and in the construction industry (for example, transmission towers, and transportation infrastructure). The American Iron and Steel Institute (2011, p. 33) reported that domestic shipments of galvanized steel in 2010 were 12.2 Mt, a 46% increase from those of 2009.

The next leading end use for zinc is brass and bronze. According to the Copper Development Association (2011, p. 16), the amount of zinc consumed domestically by brass mills, copper ingot makers, and copper foundries was 210,000 t, a 3% decrease from the amount consumed in 2009. Other end uses for zinc include—in descending order by quantity—zinc-base alloys for diecasting, chemicals, and zinc semimanufactures.

Prices and Stocks

The annual average London Metal Exchange, Ltd. (LME) cash price for SHG zinc in 2010 increased by 31% from that of 2009 to $2,160.31 per metric ton (97.99 cents per pound). The LME cash price for SHG zinc averaged $1.10 per pound in January, decreased to 79 cents per pound by midyear, and then increased to $1.08 per pound by October. The December average price declined to $1.03 per pound. The annual average Platts North American producer price for SHG zinc in 2010, which was based on the LME cash price plus premium, was $1.02 per pound. Monthly average North American SHG premiums began the year at nearly 2.87 cents per pound and rose to nearly 5.03 cents per pound by yearend.

Commodity exchange inventories [LME and the Shanghai Futures Exchange (SHFE)] totaled 1.01 Mt of zinc at yearend. Stocks of SHG zinc in global LME warehouses totaled 701,425 t at the close of the year, a 43% increase from the closing stock level in 2009. Much of this increase was attributed to increases in zinc inventories at warehouses in Malaysia and the United States—mainly, New Orleans, LA. At yearend, U.S. warehouses held 73% of LME stocks. At yearend 2010, the SHFE held 309,000 t of zinc, an 80% increase from that of 2009.

World Review

Global zinc mine production increased by 6% in 2010 from that of 2009 to approximately 12 Mt (table 10). Production increases in Australia, China, and Mexico more than offset substantial decreases in Canada, Ireland, and Peru. China (31% share of global production), Australia (12%), and Peru (12%) were the three leading producers of zinc in concentrate in 2010. Global zinc mine capacity increased by 481,000 t by yearend. Most of the net increase in capacity was as a result of mine reopenings, including Glencore's Iscaycruz Mine in Peru, Mungana Goldmine's Mungana Mine in Australia, and Nyrstar's Tennessee Mines. An expansion of the Jingding Zinc's Lanping Mine in China also significantly contributed to the capacity increase. There were no significant mine closures in 2010 (International Lead and Zinc Study Group, 2011b, p. 6).

Global zinc metal production increased 13% in 2010 from that of 2009 to 12.7 Mt (table 11) owing to the reversal of many production cutbacks at smelters that took place in 2009 owing to deteriorating market conditions. China (41% share of global production), the Republic of Korea (6%), Canada (5%), India (5%), and Japan (5%) were the leading producers of refined zinc metal in 2010.

According to ILZSG, zinc consumption increased 16% in 2010 from that of 2009 to 12.5 Mt owing to a recovery from the economic crisis. Significantly contributing to the year-on-year increase was continued growth in China leading to a 13% consumption increase and a recovery in Europe that resulted in a 29% increase in zinc consumption (International Lead and Zinc Study Group, 2011c).

Outlook

ILZSG forecast zinc consumption in 2011 to increase by 2% from that in 2010 to 12.85 Mt. China's apparent consumption was expected to increase a modest 2% as a result of a destocking of unreported inventories. Europe's consumption was forecast to increase by 3%. Notable increases in consumption were also expected in Brazil, India, and Turkey (International Lead and Zinc Study Group, 2011a).

World mine production was expected to increase by 4% in 2011 to 12.8 Mt owing to increased production in China, India, Kazakhstan, Mexico, and Russia, despite declines predicted in Australia and Peru. Refined metal production was expected to increase by 3% to 13.2 Mt owing to increases in China, India, and the Republic of Korea. Overall, the zinc metal market in 2011 was forecast to remain in a substantial surplus of 317,000 t followed by smaller surplus in 2012 (International Lead and Zinc Study Group, 2011a).

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TABLE 1
SALIENT ZINC STATISTICS[1]

		2006	2007	2008	2009	2010
United States:						
Production:						
Domestic ores, contained zinc	metric tons	727,000	803,000	778,000	736,000	748,000
Domestic ores, recoverable zinc	do.	699,000	769,000	748,000	710,000	723,000
Value, recoverable zinc	thousands	$2,450,000	$2,620,000	$1,470,000	$1,220,000	$1,620,000
Refined zinc:						
At primary smelters	metric tons	113,000	121,000	125,000	94,000	120,000
At secondary smelters[e]	do.	156,000	157,000	161,000	109,000	129,000
Total	do.	269,000	278,000	286,000	203,000	249,000
Exports:						
Ores and concentrates, zinc content	do.	825,000	816,000	725,000	785,000	752,000
Refined (slab) zinc	do.	2,530	8,070	3,250	2,960	4,200
Zinc plates, sheets, strip, and foil	do.	3,780	4,310	4,970	6,160	7,380
Imports for consumption:						
Ores and concentrates, zinc content	do.	383,000	271,000	63,200	74,200	32,200
Refined (slab) zinc	do.	895,000	758,000	725,000	686,000	671,000
Zinc plates, sheets, strip, and foil	do.	2,050	2,160	3,330	3,010	3,440
Reported stocks of slab zinc, December 31:						
Producer and consumer	do.	60,000	55,000	56,000	49,000	57,600
Government stockpile	do.	15,300	7,730	7,490	7,490	7,490
Consumption, refined zinc:						
Reported	do.	501,000	436,000	370,000	306,000	475,000
Apparent[2]	do.	1,190,000	1,040,000	1,010,000	893,000	907,000
Price[3]						
North American	cents per pound	158.89	154.40	88.93	77.91	101.98
London Metal Exchange, cash	do.	148.53	147.03	85.01	75.06	97.99
World production:						
Mine	thousand metric tons	10,300	11,000	11,700 [r]	11,400 [r]	12,000
Smelter	do.	10,800	11,400	11,700	11,300 [r]	12,700 [e]

[e]Estimated. [r]Revised. do. Ditto.

[1] Data are rounded to no more than three significant digits, except prices; may not add to totals shown.

[2] Domestic production plus net imports, plus adjustments for Government and industry stock changes.

[3] Special High Grade. Source: Platts Metals Week.

TABLE 2
MINE PRODUCTION OF RECOVERABLE ZINC IN THE UNITED STATES, BY STATE[1]

(Metric tons)

State	2009	2010
Alaska[2]	661,000	628,000
Other	49,600 [3]	94,400 [4]
Total	710,000	723,000

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Data based, in part, on publicly available information.

[3] Includes production from Idaho, Missouri, Montana, Tennessee, and Washington.

[4] Includes production from Idaho, Missouri, and Tennessee.

TABLE 3
LEADING ZINC-PRODUCING MINES IN THE UNITED STATES IN 2010, IN ORDER OF OUTPUT[1]

Rank	Mine	County and State	Operator	Source of zinc
1	Red Dog	Northwest Arctic, AK	Teck Alaska Inc.	Zinc-lead ore.
2	Greens Creek	Juneau, AK	Hecla Mining Co.	Zinc-silver ore.
3	East Tennessee Zinc Complex[2]	Jefferson and Knox, TN	Nyrstar NV	Zinc ore.
4	Middle Tennessee Zinc Complex[3]	Smith, TN	do.	Do.
5	Brushy Creek	Reynolds, MO	Doe Run Resources Corp.	Lead ore.
6	Lucky Friday	Shoshone, ID	Hecla Mining Co.	Silver ore.
7	Buick	Iron, MO	Doe Run Resources Corp.	Lead ore.
8	Fletcher	Reynolds, MO	do.	Do.
9	Viburnum (#29 and #35)	Washington and Iron, MO	do.	Do.
10	Sweetwater	Reynolds, MO	do.	Do.

Do., do. Ditto.

[1] The mines on this list accounted for more than 99% of recoverable U.S. zinc mine production in 2010.

[2] Coy, Immel, and Young Mines.

[3] Cumberland, Elmwood, and Gordonsville Mines.

TABLE 4
REPORTED PRODUCTION OF ZINC PRODUCTS FROM ZINC-BASE SCRAP IN THE UNITED STATES[1]

(Metric tons)

Products	2009	2010
Redistilled slab zinc	115,000	130,000
Other zinc metal products[2]	1,540	2,190
Zinc in chemical products	W	W
Zinc dust	22,200	22,400

W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Includes electrogalvanizing anodes, remelt die-cast slab, and other metal alloys.

TABLE 5
ZINC RECOVERED FROM SCRAP PROCESSED IN THE UNITED STATES, BY TYPE OF SCRAP[1]

(Metric tons)

	2009	2010
Type of scrap:		
New scrap:		
Zinc-base	82,900	90,700
Copper-base	111,000	117,000
Magnesium-base	100	123
Total	194,000	208,000
Old scrap:		
Zinc-base	70,000	114,000
Copper-base	8,290 r	7,800
Aluminum-base	533 r	652
Magnesium-base	14	14
Total	78,900 r	123,000
Grand total	273,000	331,000

rRevised.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 6
U.S. REPORTED CONSUMPTION OF ZINC IN 2010, BY INDUSTRY USE AND GRADE[1]

(Metric tons)

Industry use	Special High Grade	High Grade	Continuous Galvanizing Grade	Controlled Lead Grade	Prime Western	Remelt and other grades	Total
Galvanizing	105,000	86,900	120,000	718	56,200	91	369,000
Zinc-base alloys	34,900	169	--	--	--	--	35,000
Brass and bronze	40,800	4,860	--	--	223	--	45,800
Other	24,100	40	--	--	110	875	25,100
Total	205,000	91,900	120,000	718	56,500	966	475,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

TABLE 7
U.S. EXPORTS OF ZINC ORES AND CONCENTRATES, BY COUNTRY[1]

	2009		2010	
	Quantity (metric tons, zinc content)	Value (thousands)	Quantity (metric tons, zinc content)	Value (thousands)
Australia	27,400	$19,500	48,800	$61,800
Belgium	27,400	25,600	33,500	39,000
Canada	226,000	151,000	146,000	192,000
China	44,900	43,900	60,300	79,800
Costa Rica	--	--	2	15
Denmark	5	3	--	--
El Salvador	3	12	5	18
Finland	26,500	26,600	32,500	39,500
France	--	--	3	14
Germany	6,090	4,330	33,300	37,400
India	104	90	--	--
Israel	--	--	190	108
Italy	42,700	40,500	12,200	13,500
Japan	79,600	59,600	139,000	154,000
Korea, Republic of	189,000	167,000	130,000	142,000
Mexico	12	15	(2)	4
Panama	(2)	3	4	22
Singapore	--	--	62	168
Spain	116,000	118,000	116,000	143,000
Suriname	1	4	--	--
United Kingdom	46	26	51	29
Total	785,000	656,000	752,000	903,000

-- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 8
U.S. EXPORTS OF ZINC COMPOUNDS[1]

	2009		2010	
	Quantity (metric tons, gross weight)	Value (thousands)	Quantity (metric tons, gross weight)	Value (thousands)
Chromates of zinc or of lead	56	$293	35	$362
Lithopone	666	3,000	725	3,350
Zinc chloride	1,800	2,750	1,930	2,950
Zinc oxide	17,300	31,100	16,700	36,700
Zinc sulfate	1,030	1,610	1,870	2,360
Zinc sulfide	4,510	8,720	5,600	7,950

[1] Data are rounded to no more than three significant digits.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF ZINC COMPOUNDS[1]

	2009		2010	
	Quantity (metric tons, gross weight)	Value (thousands)	Quantity (metric tons, gross weight)	Value (thousands)
Chromates of zinc or of lead	32	$101	168	$701
Lithopone	1,550	1,520	1,300	1,560
Zinc chloride	249	964	405	1,290
Zinc oxide	69,200	98,500	94,300	185,000
Zinc sulfate	31,700	23,000	37,500	32,300
Zinc sulfide	1,570	2,990	2,570	4,770

[1] Data are rounded to no more than three significant digits.

Source: U.S. Census Bureau.

TABLE 10
ZINC: WORLD MINE PRODUCTION, BY COUNTRY[1, 2]

(Metric tons, zinc content of concentrate and direct shipping, unless otherwise specified)

Country	2006	2007	2008	2009	2010
Algeria	572	--	--	--	--
Argentina	29,808	27,025	30,349	31,869[r]	30,000[e]
Armenia	2,932	2,585	4,200	3,800[r]	7,900
Australia	1,362,000	1,514,000	1,519,000	1,290,000	1,479,000
Bolivia	172,747	214,053	383,619[r]	430,879[r]	411,409
Bosnia and Herzegovina[e]	500[r]	2,600[r]	4,700[r]	3,400[r]	4,000
Brazil	185,211	193,887	173,933	169,000[r]	175,000
Bulgaria	13,500[r]	12,200[r]	10,600[r]	10,700[r]	10,000[e]
Burma	8,000[r]	10,000[r]	7,000[r]	6,000[r]	7,000
Canada	637,956	630,485[r]	750,502[r]	698,901	648,905[p]
Chile	36,238	36,453	40,519	27,801	27,662
China	2,840,000	3,040,000	3,340,000[r]	3,330,000[r]	3,700,000
Congo (Kinshasa)	16,831	18,500	13,523[r]	12,843[r]	9,223
Finland	35,700	38,900	27,800	30,233	55,562
Greece	16,414	19,549	22,694	18,126	19,976
Guatemala	6,000	20,000	14,000	--	--
Honduras	37,646	29,211	28,462	36,370	33,839
India	501,700	538,900	613,600	695,000	700,000
Iran[e]	164,000	100,000	69,267[r, 3]	80,000[r]	100,000
Ireland	425,756	400,898	398,158	385,670	342,434
Japan	7,169	--	--	--	--
Kazakhstan	451,000[r]	457,000[r]	469,000[r]	485,000[r]	500,000
Korea, North[e]	67,000[r]	70,000[r]	50,000[r]	30,000[r]	40,000
Korea, Republic of	16	2,034[r]	1,836[r]	2,221[r]	355
Kosovo[4]	2,230	2,460	4,900	3,690	4,000[e]
Laos	1,100	3,000[r]	2,200[r]	3,400[r]	3,000[e]
Macedonia	11,000	24,000	29,000	35,000[r]	35,000[e]
Mexico	432,347	426,509	397,306	384,478[r]	518,429
Mongolia	54,850	77,350	71,800[r]	78,800[r]	56,300
Morocco	95,000	57,700	96,900	48,600[r]	61,900
Namibia[5]	55,455	46,335	38,319	48,856[r]	53,624
Pakistan	--	--	--	1	10
Peru	1,203,364	1,444,381	1,602,597	1,509,129	1,470,450
Philippines	--	7,394[r]	1,619	10,035	9,268
Poland	126,600[r]	129,600[r]	132,400[r]	115,500[r]	88,000
Portugal	7,505	24,380	39,254	501	6,422
Romania	8,052	1,000	--	--	--
Russia[e]	190,000	185,000	204,000	225,000	269,000
Saudi Arabia	983	716	3,663	5,000[r, e]	5,000[e]
Serbia[e]	2,000[3]	1,000[3]	1,000	1,000	1,000
South Africa	34,444	30,859	29,002	28,159	35,824
Spain	--	--	--	1,200[r]	17,318
Sweden	210,029	214,576	188,048	192,538	198,686
Thailand	32,100	32,921	17,811	34,000	25,529
Turkey	59,000	71,000	73,000	78,000[r]	88,000[e]
United States	727,000	803,000	778,000	736,000	748,000
Vietnam[e]	45,000	45,600[r]	45,600[r]	45,600[r]	45,000
Total	10,300,000	11,000,000	11,700,000[r]	11,400,000[r]	12,000,000

[e] Estimated. [p] Preliminary. [r] Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Table includes data available through July 7, 2011.

TABLE 10—Continued
ZINC: WORLD MINE PRODUCTION, BY COUNTRY[1,2]

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[3] Reported figure.

[4] On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

[5] Does not include ores sent to solvent extraction-electrowinning plant.

TABLE 11
ZINC: WORLD SMELTER PRODUCTION, BY COUNTRY[1,2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
Algeria, primary[e]	30,000	30,000	30,000	30,000	30,000
Argentina:					
Primary	42,584	42,876	39,479	32,989 [r]	40,000
Secondary	3,407	3,430	3,158	2,639 [r]	3,000
Total	45,991	46,306	42,637	35,628 [r]	43,000
Australia:					
Primary[4]	463,000	502,000	499,000	525,000	499,000 [5]
Secondary[e]	6,000	6,000	6,000	6,000	6,000
Total	469,000	508,000	505,000	531,000	505,000 [5]
Belgium, primary	251,000	241,000	251,000	26,000	260,000
Brazil, primary	272,311	265,126	248,874	250,000 [e]	250,000
Bulgaria, primary and secondary	95,341	99,992	99,699 [r]	92,676 [r]	88,000 [5]
Canada, primary	824,464	802,103	764,312	685,504	691,222 [p, 5]
China, primary and secondary[e]	3,170,000	3,740,000	4,000,000	4,280,000 [r]	5,160,000
Czech Republic, secondary[e]	-- [r]	-- [r]	-- [r]	-- [r]	--
Finland, primary	282,238	305,543	297,722	295,049 [r]	307,144 [5]
France, primary	127,777	129,110	117,861	161,000	163,000
Germany, primary and secondary	342,566	294,735	292,284	153,000 [r, e]	165,000
India, primary and secondary	443,900	453,800	567,800	606,100 [r]	684,300 [5]
Iran[e]	140,000	90,000	60,000 [r]	65,000 [r]	65,000
Italy, primary and secondary[e]	109,000 [5]	109,000	100,000	100,000	100,000
Japan:					
Primary	504,532	495,632 [r]	502,910 [r]	429,165 [r]	458,648 [5]
Secondary	148,715	143,063 [r]	147,957 [r]	111,439 [r]	115,359 [5]
Total	653,247	638,695 [r]	650,867 [r]	540,604 [r]	574,007 [5]
Kazakhstan, primary and secondary	364,821	358,226	365,572 [r]	327,873 [r]	318,800 [5]
Korea, North, primary and secondary[e]	72,000	75,000	75,000	75,000	75,000
Korea, Republic of, primary	662,521	670,000 [r]	738,000	751,179 [r]	717,100 [5]
Kosovo, primary[6]	--	--	--	5,487	5,500
Mexico, primary	279,734	321,932	305,409	300,000 [e]	300,000
Namibia[7]	129,900	150,080	145,400	153,815 [r]	151,688 [5]
Netherlands, primary	238,274	224,838	239,462	224,000	264,000
Norway, primary	160,670	157,027	145,469	138,973	148,862 [5]
Peru, primary	175,250	162,375	190,324	149,494 [r]	261,978 [5]
Poland, primary and secondary	134,000	142,000	142,600 [r]	139,100 [r]	149,000 [5]
Romania, primary and secondary	44,000 [r]	58,000 [r]	62,000	4,000 [r, e]	-- [5]
Russia, primary and secondary[e]	240,000	260,000	260,000	225,000	260,000
Serbia, primary and secondary[e]	15,000 [5]	--	--	--	--

See footnotes at end of table.

TABLE 11—Continued
ZINC: WORLD SMELTER PRODUCTION, BY COUNTRY[1, 2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010[e]
South Africa, primary	90,000	101,000	87,000	87,000	90,000 [5]
Spain, primary and secondary	507,440	494,090	456,050	500,776	501,000
Thailand, primary	94,779	99,337	107,753	104,695 [r]	100,000
United States:					
Primary	113,000	121,000	125,000	94,000	120,000 [5]
Secondary[e]	156,000	157,000	161,000	109,000	129,000
Total	269,000	278,000	286,000	203,000	249,000
Uzbekistan, primary	45,000 [e]	71,800	70,445	40,000 [e]	40,000
Grand total	10,800,000	11,400,000	11,700,000	11,300,000 [r]	12,700,000
Of which:					
Primary	4,660,000 [r]	4,740,000 [r]	4,760,000 [r]	4,330,000 [r]	4,750,000
Secondary	314,000 [r]	309,000 [r]	318,000 [r]	230,000 [r]	253,000
Undifferentiated	5,810,000 [r]	6,320,000 [r]	6,630,000 [r]	6,720,000 [r]	7,720,000

[e]Estimated. [p]Preliminary. [r]Revised. -- Zero.

[1] World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Wherever possible, detailed information on raw material source of output (primary—directly from ores, and secondary—from scrap) has been provided. In cases where raw material source is unreported and insufficient data are available to estimate the distribution of the total, that total has been left undifferentiated (primary and secondary). To the extent possible, this table reflects metal production at the first measurable stage of metal output. Table includes data available through July 7, 2011.

[3] In addition to the countries listed, Israel also produces small amounts of secondary zinc, but available information is inadequate to make reliable estimates of output levels.

[4] Excludes zinc dust.

[5] Reported figure.

[6] On February 17, 2008, the Kosovo Assembly declared independence from Serbia.

[7] Special high-grade electrowon cathodes from Anglo American plc's Skorpian solvent extraction-electrowinning plant.

ZIRCONIUM AND HAFNIUM

By Joseph Gambogi

Domestic survey data and tables were prepared by Connie Lopez, statistical assistant, and the world production table was prepared by Lisa D. Miller, international data coordinator.

In 2010, the global economy began to recover, and consumption of zirconium ores and concentrates increased. In response to increased demand, producers revisited expansion and development programs. World production of zirconium mineral concentrates in 2010, excluding U.S. production, was about 1.25 million metric tons (Mt) compared with 1.18 Mt in 2009. The primary source of zirconium was the mineral zircon ($ZrSiO_4$), principally found in heavy-mineral sands. A relatively small quantity of zirconium was derived from the mineral baddeleyite, a natural form of zirconium oxide (ZrO_2) produced from a single source at Kovdor, Russia. In 2010, the leading producers of zircon were Australia and South Africa. Zircon was also the primary source of hafnium, where zirconium and hafnium are contained in zircon at a ratio of about 50 to 1. The leading producers of zirconium and hafnium metal were France, Russia, and the United States.

Because of improving economic conditions, U.S. production of milled zircon increased by 22% compared with that of 2009. The United States remained a net exporter of zirconium ore and concentrates. U.S. exports of zirconium ore and concentrate increased by 20%, and imports of zirconium ore and concentrates increased by 59% compared with those of 2009. With the exception of prices and referenced data, all survey data in this report have been rounded to no more than three significant digits. Totals and percentages were calculated from unrounded numbers.

Production

Zircon is a coproduct of the mining and processing of heavy-mineral sands for the titanium minerals ilmenite and rutile. In 2010, U.S. producers of zircon were DuPont Titanium Technologies (DuPont) (a subsidiary of E.I. du Pont de Nemours & Co.) and Iluka Resources, Inc. (a wholly owned subsidiary of Australian company Iluka Resources Ltd.). DuPont produced zircon from its heavy-mineral sands operation near Starke, FL. Iluka produced zircon from its heavy-mineral sands operations at Stony Creek, VA.

Data for zirconium and hafnium manufactured materials were developed by the U.S. Geological Survey (USGS) from a voluntary survey of domestic operations. Of the 39 operations surveyed, 15 responded, representing 85% of milled zircon production. Data for nonrespondents were estimated on the basis of prior-year levels adjusted for the effect of economic conditions. Domestic production of milled zircon was 46,900 metric tons (t). Domestic production of zircon concentrate in 2010 increased compared with that of 2009. Insufficient data were available to determine stocks of zircon and zirconium oxide as well as production of zirconium oxide (table 1).

Data for zircon concentrates were developed from a second voluntary survey of domestic mining operations. The two domestic zircon producers responded. Data on domestic production and consumption of zircon concentrates were withheld to avoid disclosing company proprietary data. In February, Iluka's Stony Creek operations were brought to full production capacity after the company curtailed production in 2009 (Iluka Resources Ltd., 2011, p. 11). U.S. producers of zirconium and hafnium metal were ATI Wah Chang (an Allegheny Technologies, Inc. business unit) in Albany, OR, and Western Zirconium (a subsidiary of Westinghouse Electric Co.) in Ogden, UT.

Milled zircon (flour) was produced from zircon sand by at least five companies, and zirconium chemicals were produced by about a dozen companies. Wah Chang doubled its reactor-grade zirconium sponge production capacity to 3,630 metric tons per year (t/yr) (Allegheny Technologies Inc., 2011, p. 3).

Industrial Minerals Corp. Ltd. (IMC) continued the development of its Coos Bay, OR, heavy-minerals project. In 2010, IMC began construction of the processing plant and continued its permiting process. IMC expected to begin producing chromite, garnet, and zircon in 2012. Estimated proven ore reserves at Coos Bay were 7.9 Mt with a heavy-mineral grade of 21.5% and zircon grade of 0.4% (Industrial Minerals Corp. Ltd., 2010, p. 2, 14).

Consumption

After decreasing significantly in 2009, global consumption of zircon rebounded to close to that in 2008 and was estimated to be 1.3 Mt in 2010 (Roskill Information Services Ltd., 2011, p. 2). Globally, the leading end uses for zircon in 2010 in descending order were ceramics, zirconia and chemicals, refractory, and foundry and casting (Roskill Information Services Ltd., 2011, p. 4). Zircon is also used as a natural gemstone and may be processed to produce cubic zirconia, a synthetic gemstone and diamond simulant.

Zirconium metal is used in corrosive environments, nuclear fuel cladding, and various specialty alloys. The principal uses of hafnium were in high-temperature ceramics, nickel-base superalloys, nozzles for plasma arc metal cutting, and nuclear control rods.

Zirconium oxide exhibits high light reflectivity and good thermal stability and is primarily used as an opacifier and pigment in glazes and colors for pottery and other ceramic products. Yttria-stabilized zirconia (YSZ) was used in the manufacture of oxygen sensors that control combustion in automobile engines and furnaces. YSZ was also used in the manufacture of a diverse array of products, including cubic zirconia, fiber optic connector components, refractory coatings, and engineering and structural ceramics. YSZ was used in dental applications, such as bridges, crowns, and inlays, because it has two to three times the fracture resistance and 1.4 times the strength of similar alumina products.

Zircon, used for facings on foundry molds, increases resistance to metal penetration and gives a uniform finish to castings. Milled or ground zircon was used in refractory paints for coating the surfaces of molds. In the form of refractory bricks and blocks, zircon was used in furnaces and hearths for containing molten metals. Glass tank furnaces use fused-cast and bonded alumina-zirconia-silica-base refractories. Baddeleyite is used principally in the manufacture of alumina-zirconia abrasive and in ceramic colors and refractories.

Ammonium- and potassium-zirconium carbonates were used as paper and board coatings or insolubilizers for high-quality print performance. Zirconium chemicals were also used in inks to promote adhesion to metals and plastics and as crosslinkers in polymers and printing inks.

Because of its low thermal neutron absorption cross section, hafnium-free zirconium metal is used as cladding for nuclear fuel rod tubes. Hafnium is used in nuclear control rods because of its high thermal neutron absorption cross section. Commercial-grade zirconium, unlike nuclear grade, contains hafnium and is used in the chemical process industries because of its excellent corrosion resistance. Hafnium metal also is used as an alloy addition in superalloys.

Prices

Rising consumption caused prices of zirconium ores and concentrates to increase in 2010. At yearend, the published price range of standard grade, bulk, domestic zircon was $830 to $890 per metric ton, up from $800 to $860 per ton at yearend 2009 (table 2). The unit value of imports also increased slightly, and the import volume increased by 59%. The average unit value of imported zirconium ore and concentrates (primarily zircon sand) was $1,200 per ton in 2010.

No published prices were available for zirconium metal. In 2010, the average unit value of imported unwrought powder from France was $74.30 per kilogram, a 44% increase from that in 2009. The average duty-paid unit value of imported unwrought hafnium including sponge and powder from France was $453 per kilogram, a 4% decrease from that in 2009.

Foreign Trade

In 2010, Australia (70%) and South Africa (24%) supplied most of the imports of ores and concentrates, and the United States remained a net exporter of zirconium ore and concentrates (table 4). Net exports of zirconium ore and concentrates increased by 3% (table 3). The majority of zirconium metal was exported in wrought products classified as "Other zirconium" in the Harmonized Tariff Schedule (HTS) category 8109.90.0000. Imports of zirconium and hafnium metal in the HTS categories 8109 and 8112 totaled 1,170 t and increased by 19% and 55%, respectively, compared with those of 2009. Imports of germanium and zirconium oxides increased by 4%, with China (38%) the leading import source of oxides. Domestic imports of ferrozirconium alloys increased to 45 t from 0.249 t in 2009. China (98%) was the leading import source of ferrozirconium.

World Review

Excluding U.S. production, world production of zirconium mineral concentrates in 2010 was about 1.25 Mt, a 4% increase compared with revised 2009 data (table 5). Australia and South Africa supplied about 76% of all production outside the United States. The leading zircon producers were Iluka, Richards Bay Minerals, and Exxaro Resources Ltd. China was the leading consuming country. Based on metal oxide content, world reserves of zirconium were estimated to be 56 Mt. After curtailing production in 2009, in 2010 producers were moving to increase production and renew exploration and development efforts.

Australia.—Owing to improved market conditions, Iluka significantly increased its global production of zircon (413,000 t in 2010 compared with 263,000 t in 2009). The increase was largely because of the startup of its operations in the Eucla Basin, South Australia (151,000 t), and its operations in the Murray Basin, Victoria (158,000 t). Production from the Perth Basin, Western Australia, contributed 46,200 t to the global total (Iluka Resources Ltd., 2011, p. 18–22).

In New South Wales, Alkane Resources Ltd. continued to develop its Dubbo Zirconia project. In 2010, the company operated a demonstration pilot plant to validate the process flowsheet, provide data for cost estimates, and generate product for market evaluation. A definitive feasibility study was scheduled for completion in 2011. Potential products from the project included zirconia, zirconium basic sulfate, zirconium carbonate, and zirconium hydroxide. Owing to high demand for rare earths, the company was also researching the recovery of rare-earth elements (Alkane Resources Ltd., 2011, p. 2).

In August, the mining license for Astron Ltd.'s Donald mining project was approved by the Department of Primary Industries, Victoria, and mine and plant designs were completed during the year. Ore reserves were estimated to be 305 Mt, with 6.2% heavy minerals containing 19% zircon (Astron Ltd., 2010a, b).

Gunson Resources Ltd. completed a definitive feasibility study for its Coburn heavy-minerals project in Western Australia. Reserves of zircon in the Coburn deposit were estimated to be 850,000 t supporting a mine life of 17 years, with a target production rate of 40,000 t/yr (Gunson Resources Ltd., 2010, p. 9).

Matilda Zircon Ltd. continued the development of zircon-rich heavy-minerals deposits in the Northern Territory and Western Australia. In 2010, Matilda Zircon formed an agreement with Chinese zircon consumer Tricoastal Minerals Co. to take all heavy-mineral concentrate from the Tiwi Islands operations and supply $2.5 million in loans and share placements to assist in development of the Lethbridge Mine, which began production in June. At yearend, the company expected approval from the Western Australian Minister of the Environment to proceed with the development of the Keysbrook deposit, 70 kilometers south of Perth. Mining at Keysbrook was expected to begin in 2012, with an 8-year mine life (Matilda Zircon Ltd., 2010).

Canada.—Titanium Corp. continued its research into the recovery of bitumen, volatile organic compounds, and heavy minerals, including zircon, from mined oil sand tailings. In

2010, Titanium Corp. commissioned a demonstration pilot plant at the Canadian Government's Canmet testing facilities in Devon, Alberta. Pilot studies were conducted in June through September, with additional studies planned for 2011 (Titanium Corp., 2010, p. 4).

China.—As a leading producer of ceramic tiles, steel, and zirconium chemicals, China was the leading consumer of zircon, with about 40% of the total global zircon consumed (Porter, 2010, p. 7). China led the world in production of zirconium chemicals, with a total production capacity of 300,000 t/yr, including 170,000 t/yr of zirconium oxychloride (ZOC), an intermediate to many zirconium chemicals and zirconium metal. In 2010, the leading export destinations for China's ZOC were Japan (49%) and the United States (33%). China's production of ZOC was forecast to rise to 230,000 t by 2015 (Roskill Information Services, 2011, p. 97.)

Areva (50%) and China National Nuclear Corp. (50%) formed a joint venture called CNNC Areva Shanghai Tubing (CAST), which was expected to produce zirconium alloy tubes for fuel assemblies. The CAST facility was scheduled to begin production in 2020 near Shanghai (World Nuclear News, 2010a).

Indonesia.—In 2010, Matilda Zircon's Kalimantan heavy-mineral concentration plant exploration program was placed on care-and-maintenance status while focusing on its Australian projects. Matilda intended to reassess the Indonesian project in 2011 (Matilda Zircon Ltd., 2010, p. 4).

Kenya.—In July, Base Resources Ltd. acquired the Kwale Mineral Sands project from Vaaldiam Mining Inc. In 2010, an updated definitive feasibility study was underway and was scheduled for completion in 2011. The company expected the Kwale operation to be in production by 2013, with a production capacity of 35,000 t/yr of zircon (Base Resources Ltd., 2011).

Korea, Republic of.—The Atomic Energy of Canada Ltd. (AECL) was contracted by Korea Hydro and Nuclear Power to refurbish the CANDU 6 reactor at the Republic of Korea's Wolsong 1 nuclear powerplant. Under the terms of the contract, AECL completed the removal and replacement of 380 calandria tubes, pressure tubes, and end fittings. A calandria is constructeed like a shell-and-tube heat exchanger. Fuel channels consist of an inner pressure tube, which contains the fuel bundle and the heavy water primary coolant, and an outer calandria tube. Each calandria tube is made of zirconium alloy and is approximately 6 meters long and 13 centimeters in diameter. CANDU reactors were designed to undergo refurbishment after approximately 25 years of operation (World Nuclear News, 2010b).

Mozambique.—Kenmare Resources plc was ramping up production at its Moma heavy-minerals operation. Zircon production at Moma in 2010 was 37,100 t, a 76% increase compared with that in 2009. In October, a breach of a settling pond allowed water to flood into a nearby village, causing one fatality. The mine was idled for 4 weeks while repairs and new safety measures were implemented. At yearend, Kenmare was proceeding with an expansion that would increase production capacity by about 50% (Kenmare Resources plc, 2011).

Russia.—ARZM Uranium Holding Co. continued to develop the Lukoyanovskoye heavy-minerals sands deposit near Nizhny Novgorod. By 2014, the company planned to begin production of heavy-mineral concentrates including up to 35,000 t/yr of zircon. ARZM planned to supply mineral concentrates to OJSC TVEL (ARZM Uranium Holding Co., 2010, p. 40).

Senegal.—A feasibility study of Mineral Deposits Ltd.'s Grande Cote heavy-minerals deposit was completed in 2010 enabling the company to secure financing to develop the project. Construction of the mine and separation plants was expected to begin in 2011, and initial production was scheduled for 2013. Once the mine and separation plants are fully commissioned, the company expected to produce an average of 575,000 t/yr of ilmenite, 80,000 t/yr of zircon, 11,000 t/yr of leucoxene, and 6,000 t/yr of rutile (Mineral Deposits Ltd., 2010, p. 16).

South Africa.—Exxaro Resources Ltd. increased zircon production in South Africa to 161,000 t in 2010 from 152,000 t in 2009 through improved recovery of zircon at its Namakwa Sands operation. In 2010, Exxaro's Hillendale Mine neared the end of its life; however, plans were underway to develop the Fairbreeze deposit as a substitute for the waning production from the Hillendale Mine (Exxaro Resources Ltd., 2011, p. 53).

Rio Tinto Plc invested $158 million in a tailings treatment facility at its Richards Bay Minerals heavy-minerals operation. At yearend, the treatment facility neared completion and was scheduled to begin production in the first quarter of 2011. Heavy-mineral concentrates, including zircon, were to be recovered from about 30 years accumulation of mine tailings (Industrial Minerals, 2010).

Vietnam.—In an effort to assist the domestic mining industry, the Government of Vietnam continued to suspend a ban on exports of titanium and zirconium mineral concentrates designed to encourage the production of value-added products. Producers were permitted to export through the end of 2010 (Mineral Sands Report, 2009).

Outlook

The consumption of zirconium mineral concentrates was expected to increase with demand from consumers such as the ceramics, metals, and chemicals industries. Because the use of these materials is pervasive in the general economy, economic growth may be used to estimate trends in zirconium consumption. The International Monetary Fund projected that world economic growth would be about 4.3% in 2011 and 4.5% in 2012. China was expected to lead global economic growth with 9.6% in 2011 and 9.5% growth expected in 2012. China's continued growth was expected to significantly increase in zircon consumption during the long term. The U.S. economy was projected to increase by 2.2% in 2011 and 2.6% in 2012 (International Monetary Fund, 2011). During the long term, the U.S. Congressional Budget Office projected the U.S. gross domestic product growth annually to average 3.6% from 2013 to 2016 (U.S. Congressional Budget Office, 2011).

In recent years, new mines were bought online in Australia, Mozambique, and South Africa; however, the global financial crisis curtailed production and delayed the development of several mining projects. This constricted supply together with rising demand are likely to create a scarcity of zircon though 2013.

Construction and operation of new nuclear powerplants throughout the world were expected to increase future demand for zirconium and hafnium metal. The International Atomic Energy Agency projection of world nuclear generating capacity was more than 73 gigawatts (GW) in net new capacity by 2020, with 546 to 803 GW in place by 2030. Total capacity at yearend 2010 was 377 GW (World Nuclear Association, 2011). Although the amount of zirconium metal varies by reactor, boiling water reactors were estimated to contain on average about 44 t of zirconium, and pressurized heavy-water reactors required about 12.5 t. Global zirconium metal consumption was projected to reach 6,500 t by 2015 (Desai, 2009).

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TABLE 1

SALIENT U.S. ZIRCONIUM STATISTICS[1]

(Metric tons)

	2006	2007	2008	2009	2010
Zircon:					
Production:					
Concentrates	W	W	W	W	W
Milled zircon	50,800	64,600	61,500	38,400	46,900
Exports	76,300	66,200	42,100	39,600	47,400
Imports for consumption[2]	36,200	20,000	34,400	14,400	22,900
Consumption, apparent[3]	W	W	W	W	W
Stocks, December 31, dealers and consumers[4]	17,600	18,000	26,600	NA	NA
Zirconium oxide:					
Production[5]	21,700	25,600	18,100	NA	NA
Exports[6]	3,340	2,400	2,970	3,050	5,630
Imports for consumption[6]	2,820	3,740	5,060	2,810	2,920
Consumption, apparent[3]	24,200	26,900	20,400	NA	NA
Stocks, December 31, dealers and consumers[4]	1,560	1,880	1,670	NA	NA
Zirconium, unwrought, waste and scrap, other:					
Exports	1,880	2,160	2,670	2,300	2,060
Imports	748	784	1,030	977	1,160
Ferrozirconium:					
Exports	491	259	316	566	569
Imports	196	400	129	(7)	45
Hafnium, unwrought, waste and scrap, other, imports	4	4	12	5	8

NA Not available. W Withheld to avoid disclosing company proprietary data.

[1] Data are rounded to no more than three significant digits.

[2] Includes insignificant amounts of baddeleyite.

[3] Defined as production plus imports for consumption minus exports plus or minus Government shipments.

[4] Excludes foundries.

[5] Excludes intermediate oxides associated with metal production.

[6] Includes germanium oxides and zirconium dioxides.

[7] Less than ½ unit.

TABLE 2

PUBLISHED YEAREND PRICES OF ZIRCONIUM MATERIALS

(Dollars per metric ton)

Material	2009	2010
Baddeleyite, contract price, cost, insurance, and freight main European port:		
Refractories/abrasive grade	2,500–3,100	2,500–3,100
Ceramic grade (98% zirconium oxide and hafnium oxide)	3,000–3,300	3,000–3,300
Zircon:		
Domestic, standard-grade, bulk	800–860	830–890
Australian, standard-grade, free on board, bulk	880–900	850–890
Zirconia, fused, monoclinic, refractory/abrasive	4,100–4,900	4,400–5,200

Source: Industrial Minerals.

TABLE 3
U.S. EXPORTS OF ZIRCONIUM, BY CLASS AND COUNTRY[1]

Class and country	HTS[2]	2009 Quantity (metric tons)	2009 Value (thousands)	2010 Quantity (metric tons)	2010 Value (thousands)
Ore and concentrates:	2615.10.0000				
Belgium		6,580	$6,850	657	$1,000
Canada		1,770	2,090	2,340	3,350
China		2,630	1,430	359	223
El Salvador		--	--	3,210	898
Germany		870	1,240	1,970	4,500
Italy		156	232	18,200	15,800
Japan		11,600	6,520	1,470	3,080
Korea, Republic of		2,320	2,060	2,080	1,870
Mexico		4,010	4,140	3,560	3,970
Netherlands		9	53	5,280	4,610
Spain		4,430	3,900	2,000	1,660
United Kingdom		1,540	2,470	1,660	3,350
Other		3,650 r	5,360 r	4,580	6,760
Total		39,600	36,300	47,400	51,100
Ferrozirconium:	7202.99.1000				
Canada		54	122	109	276
Mexico		490	983	395	791
Other		21 r	35 r	65	128
Total		566	1,140	569	1,200
Unwrought zirconium, including powder:	8109.20.0000				
China		5	158	61	2,570
France		37	1,730	75	3,260
Germany		11	356	52	1,670
Mexico		(3)	12	35	1,270
Russia		73	4,000	65	3,230
United Kingdom		24	730	109	2,650
Other		15 r	673 r	41	1,800
Total		165	7,660	438	16,400
Zirconium waste and scrap:	8109.30.0000				
Canada		27	1,590	42	2,570
France		12	208	5	45
Japan		--	--	7	192
Netherlands		--	--	10	107
Sweden		16	266	10	118
Other		2 r	41 r	8	198
Total		58	2,110	82	3,230
Other zirconium:	8109.90.0000				
Canada		442	37,200	420	33,600
China		680	62,700	328	33,800
France		149	11,600	41	3,220
Japan		205	17,500	62	5,490
Korea, Republic of		287	26,100	276	23,500
Spain		83	14,300	89	14,400
Sweden		109	9,280	143	13,000
Other		122	11,100	180	16,300
Total		2,080	190,000	1,540	143,000

r Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF ZIRCONIUM AND HAFNIUM, BY CLASS AND COUNTRY[1]

		2009		2010	
Class and country	HTS[2]	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Zirconium ore and concentrates:	2615.10.0000				
Australia		8,090	$6,910	16,100	$16,000
South Africa		5,080	7,390	5,550	7,730
Other		1,250	2,810	1,220	3,790
Total		14,400	17,100	22,900	27,500
Ferrozirconium:	7202.99.1000				
China		--	--	43	232
Other		(3)	7	2	14
Total		(3)	7	45	246
Unwrought zirconium, including powder:	8109.20.0000				
France		3	166	1	75
Germany		9	1,540	13	2,050
Japan		7	16	--	--
Kazakhstan		--	--	15	168
Other		3[r]	174[r]	2	36
Total		22	1,890	31	2,330
Zirconium waste and scrap:	8109.30.0000				
France		83	807	83	710
United Kingdom		313	842	578	1,270
Other		33[r]	247[r]	35	405
Total		429	1,900	695	2,390
Other zirconium:	8109.90.0000				
Canada		34	3,810	8	974
France		347	48,600	397	64,600
South Africa		86	112	--	--
Other		59[r]	4,000[r]	29	2,700
Total		526	56,500	435	68,300
Unwrought hafnium, including powder:	8112.92.2000				
France		4	1,910	7	3,120
Russia		(3)	31	--	--
Other		(3)[r]	145[r]	(3)	272
Total		5	2,080	8	3,390

[r] Revised. -- Zero.

[1] Data are rounded to no more than three significant digits; may not add to totals shown.

[2] Harmonized Tariff Schedule of the United States.

[3] Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 5
ZIRCONIUM MINERAL CONCENTRATES: ESTIMATED WORLD PRODUCTION, BY COUNTRY[1,2]

(Metric tons)

Country[3]	2006	2007	2008	2009	2010
Australia[4]	492,000	601,000	550,000	476,000	518,000
Brazil[4,5]	25,120	26,739	17,682	18,134	18,150 [p]
China	135,000	140,000	140,000	130,000	140,000
India	28,000	29,000	30,000	37,000 [r]	38,000
Indonesia	65,000	111,000	65,000	63,000	50,000
Malaysia	1,690 [4]	7,393 [4]	948 [r,4]	1,145 [r,4]	1,300
Mozambique	--	26,347	32,985	19,101	37,100
Russia[6]	7,500	7,136 [4]	7,000 [4]	5,000 [4]	6,000
South Africa	435,000 [r,4]	405,000 [r,4]	405,000 [r,4]	390,000 [r]	400,000
Ukraine	27,000 [r]	37,000 [r]	36,000 [r]	31,000 [r]	30,000
United States	W	W	W	W	W
Vietnam	26,100	22,000	22,000	7,000	7,000
Total	1,240,000 [r]	1,410,000 [r]	1,310,000	1,180,000	1,250,000

[p] Preliminary. [r] Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

[1] World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2] Includes data available through May 16, 2011.

[3] Small amounts of zirconium concentrates were produced in various countries; however, information is not sufficient to estimate output.

[4] Reported figure.

[5] Includes production of baddeleyite-caldasite.

[6] Production of baddeleyite concentrate averaging 98% ZrO_2.

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